PROCTOLOGIC ANATOMY

Proctologic Anatomy

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To my wife

Foreword

The names of Milligan, Morgan, and Gorsch will always be associated with the advanced knowledge of the anatomy of the pelvic outlet. It is but fitting that a man of Dr. Gorsch's experience as a teacher and a delver into anatomy should have brought all the data up to date and presented them in this compact monograph. To all surgeons, especially the embryo surgeon who hopes some day to gain proficiency as a specialist, this book will be invaluable.

JEROME M. LYNCH, M.D.

Preface to the Second Edition

Since the publication of the first edition of this book in 1941 proctology has received recognition as a separate specialty with an independent, approved, certifying Board—the American Board of Proctology.

The rapid progress and broadening interest in this field has yielded a large number of articles and several textbooks to the proctologic literature. Several contributions to the anatomic literature, notably that of Uhlenhuth, have also been of considerable proctologic interest.

The author has thoroughly reviewed and evaluated the bulk of these contributions and he would again emphasize that the diagnosis, pathogenesis, and particularly the surgery of proctologic disorders, require a basic and broad anatomic background which is not yet available to the postgraduate student or the practicing proctologist.

It has therefore been the author's purpose to again consolidate in one volume the modern and generally accepted concept of the perineopelvic anatomy and to present it in an orderly and readily comprehensible form with particular emphasis on its practical application. There has been some unavoidable repetition in doing this.

In the preparation of this edition the entire material has been revised, largely rewritten and brought up to date. Where the anatomy is still equivocal, the author has been guided by his own dissections and has offered descriptions of practical rather than academic value.

Notable revisions are the chapters on the anatomy of the anal canal, the anorectal musculature, the perineopelvic spaces and the levator ani muscle. The detailed anatomy of the pelvic

Preface to the First Edition

The author's experience in the special practice, and more particularly in the postgraduate teaching field of proctology has impressed him with the desirability of increasing the facilities for specialized anatomical training to future proctologic aspirants.

The limited anatomical training offered by the present medical school does not meet the requirements or demands for the present or future standards of proctologic practice. Special training in anatomy is not within the scope of the medical school and it is not desirable that it should be. This is a definite and important obligation to be fully assumed by the postgraduate schools.

The author is also convinced that the diagnosis, patholysis and treatment of proctologic disorders falls definitely below the standards of other medical specialties. This applies in particular to the surgical aspect of proctology.

Furthermore the fragmentary descriptions of the anatomy in the modern proctologic textbooks are probably designed for the general practitioner but can scarcely suffice as an adequate anatomic basis for special practice in the surgical field of proctology.

The practice of proctology is a complex specialty, largely surgical, in which a broad, basic anatomical background of the entire pelvic viscera is quite essential to the performance of satisfactory surgery, as well as to a correct and complete conception of the pathogenesis and clinical course of not only proctologic, but also the closely allied gastroenterologic, gynecologic and urologic diseases.

My purpose, therefore, is to present a comprehensive and simple description of the essential perineopelvic anatomy as I have actually observed it, emphasizing its more important surgical and

fascia is assuming increasing importance in the broadening scope of pelvic surgery and the chapter on this difficult subject has therefore been entirely rewritten and presented in a simple manner more readily understandable and useful to the student as well as the practicing surgeon.

If the author has in some measure bridged the gap between anatomist and practicing proctologist he will consider his efforts well repaid.

R. V. G.

Acknowledgements

Sincere thanks and due credit are extended to the authors whose illustrations have been used or to whom reference has been made.

I am indebted in particular to Dr. Eduard Uhlenhuth for his excellent illustrations on the pelvic fascia and musculature. To Dr. George Becker the author is again indebted for his photographs of additional anatomic dissections added to this edition.

To Mr. C. Naunton Morgan of London, England, I extend my sincere thanks for his helpful suggestions.

R. V. G.

pathogenic aspects and its particular application to the proctologic field.

Special consideration has been given to the important musculature of the anal canal.

I am fully appreciative that considerable anatomic detail has been omitted. However, the work was not intended to cover the entire subject of pelvic anatomy, but rather to offer it primarily from the proctologic viewpoint. If I have accomplished this in some slight degree, I shall have considered my efforts as amply rewarded.

R. V. Gorsch

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CHAPTER I

The Pelvis, Pelvic Floor and Perineal Triangles

Phylogenetically and embryologically the development of the pelvic viscera and their perineal outlets may be traced through successive stages in which the complete division of a common excretory cavity—the cloaca—finally reaches the complex adult pattern.

Progressive ontogenous development has formed the adult visceral systems. These in their functional adaptations have acquired peculiar anatomic and histologic structures which in modern medicine have come to be considered as more or less independent systems with distinctive pathologic processes.

However, the surgical specialties primarily concerned with this development—urology, gynecology and proctology—are closely allied in symptomotology and treatment. It has therefore seemed advisable to emphasize the broader pelvic outlook essential to a sound anatomic, pathogenic and surgical grasp of these closely related surgical specialties. The tendency in proctology is to narrow its scope to the anal ring.

A short review of the pelvis, the pelvic floor and its triangles is therefore included.

THE PELVIS

In its broader sense the pelvis is the large bony canal bounded anteriorly by the pubo-ischial rami, laterally by the hip bones

(the ossa innominata) and posteriorly by the sacrum. The bony wall, entirely complete above, is deficient below, the interval being partly closed by the great sacrosciatic or sacrotuberous ligament.

The pelvic viscera and the adjacent soft parts encroach somewhat on the bony pelvis. At the pelvic inlet these include the psoas, the iliacus muscles, the ureters, the pelvic nerve plexuses and the large vessels; at the pelvic outlet they include the piriformis, the obturator internus muscles and the composite musculofascial structures of the pelvic floor which, in the female, have an important functionally adaptive arrangement.

Largely as a result of obstetric practice, the true pelvis is commonly described as extending from the pelvic inlet or superior strait, or more commonly the plane of the pelvic inlet, to the pelvic outlet or inferior strait (fig. 1).

The plane of the pelvic inlet, anatomically, is bounded anteriorly by the symphysis pubis, laterally by the iliopectineal lines and posteriorly by the superior border of the first sacral vertebra and the alae of the sacrum (fig. 2).

The pelvic outlet, or inferior strait, is roughly rhomboid in outline, extending from the inferior margin of the symphysis outward, backward and downward along the rami of the pubes and ischia to the tuberosities and thence along the lower margin of the sacrotuberous ligaments to the sacrum and coccyx in the midline. The pelvic outlet corresponds to the perineum in its broader sense.

The pelvic aperture, genital hiatus or genital cleft is the interpubic interval in the pelvic outlet. It contains the visceral outlets which are enveloped by the levator ani muscles and their extensions.

The essential sex differences of the male and female pelvis are of more importance from the obstetric viewpoint. However, the broader pelvic outlet in the female, with its peculiar muscular and fascial arrangement, is also of proctologic significance to the formation of the perineopelvic spaces.

The true pelvis, extending from the pelvic inlet to the outlet, has the shape of a curved cylinder, the anterior depth of which corre-

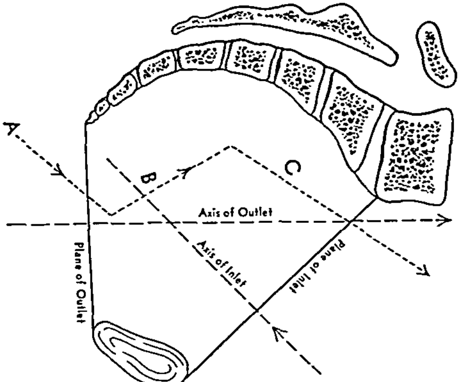


FIG. 1. The pelvic planes. A, the axis of the anal canal; B, the axis of the rectal ampulla; C, the axis of the sigmoid. These changing axes are important in procto-sigmoidoscopy.

sponds roughly to that of the symphysis pubis, while the posterior depth, of comparatively much greater dimensions, extends from the sacral promontory to the coccyx. Its axis varies gradually and follows roughly the sacrococcygeal curve (figs. 3 and 4).

In the newborn and infant the pelvis is somewhat cone-shaped and relatively much smaller than in the adult. The sacrum has yet to attain its prominent anterior curve as in the adult and the plane of the pelvic inlet is almost horizontal, factors which predispose the infant to prolapse of the rectum. During the first two years the pelvis grows rapidly. With the changing mechanics of the erect position and the increased activity in walking the sacrum descends between the ilia and by the end of the second decade the pelvis has almost assumed its adult pattern.

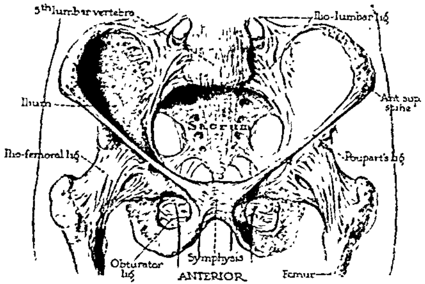


FIG. 2. The pelvic inlet from above. (Courtesy of S. H. Camp & Company.)

THE PELVIC FLOOR

The pelvic outlet is commonly described as being closed by the pelvic diaphragm or the pelvic floor. There is some looseness in the terminology referring to the pelvic floor or diaphragm; the two terms are frequently confused. Anatomically these are different structures and the terms should not be used interchangeably.

Largely as a result of the gynecologist's conception of the utero-vaginal supports, the pelvic floor has been referred to as consisting of an upper and lower portion or, loosely, an upper and lower diaphragm (fig. 5). For example, according to Johnston, two diaphragms support the uterus and this writer refers to the lower diaphragm as the pelvic floor. On the other hand, Farrar refers to the upper pelvic floor as including the levator ani muscles, commonly described, together with the coccygeal muscles and their fascia, as the pelvic diaphragm.

From the practical, if not strictly anatomic, standpoint, it appears simplest, notwithstanding the fact that the pelvic floor actually extends below the plane of the pelvic outlet, to consider the pelvic floor as including all the musculofascial strata from the peritoneum above to the skin below.

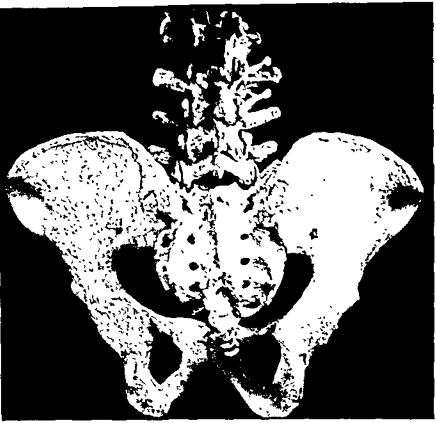


Fig. 3 (top) The pelvis from behind.

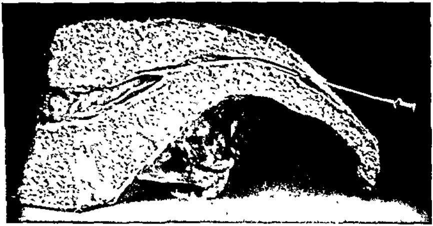


Fig. 4. (bottom) The sacral curve. (Dissection by the author.) Note the end of the dura. The needle lies in the *sacral*, not the spinal, canal.

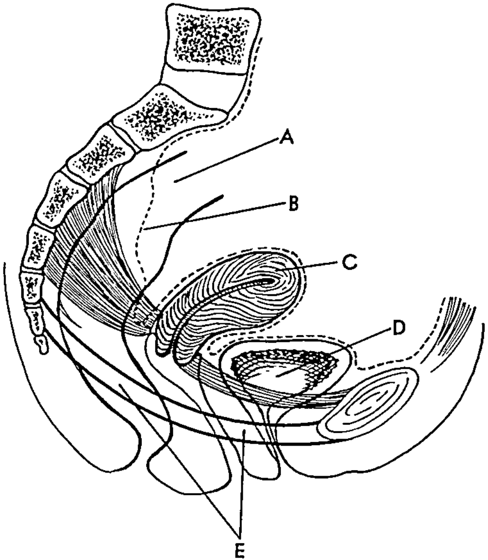


FIG. 5 The pelvic diaphragm (levator ani and coccygei muscles). This is sometimes referred to as the lower pelvic floor. The uterovesical and uterosacral supports are referred to as the upper pelvic floor. The fascial extensions from the cervico-uterine junction to the lateral aspects of the rectum are sometimes referred to as the uterorectal ligaments. (A) Rectum; (B) peritoneum; (C) uterus; (D) bladder; (E) pelvic diaphragm

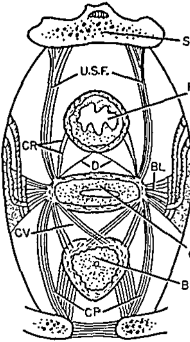


FIG. 6. Schematic transverse section of smooth muscle diaphragm. U.S.F., uterosacral fibers; C.R , cervicorectal fibers; D., decussation fibers; B.L., broad ligament fibers; C.V., cervicovesical fibers; C.P., cervicopubic fibers. Redrawn from Power, R. M. H.: The pelvic floor in parturition. *Surg., Gynec. & Obst., 83:* 296–311, 1946.

These strata include from above downward: 1) the peritoneum, 2) the extensive subserous or endopelvic fascioligamentous network with its smooth muscle component (the smooth muscle diaphragm) (fig. 6), 3) the strong supralevator fascia together with the levator ani and coccygeus muscles forming the pelvic diaphragm, 4) the urogenital diaphragm (triangular ligament), 5) the sphincteric strata, anal and urogenital.

From the gynecologic standpoint the so-called upper pelvic floor contains the main supports for the uterus, vagina and bladder in the female, e.g., the cardinal, uterosacral, pubovesical, vesicouterine, etc., ligaments, as well as the parametrial tissues and the peritoneal extensions. The upper pelvic floor also includes the ureters, the mesenteroids of the vagina, the neuro-vascular sheaths, the pelvic lymphatics and nerve plexuses (fig. 7).

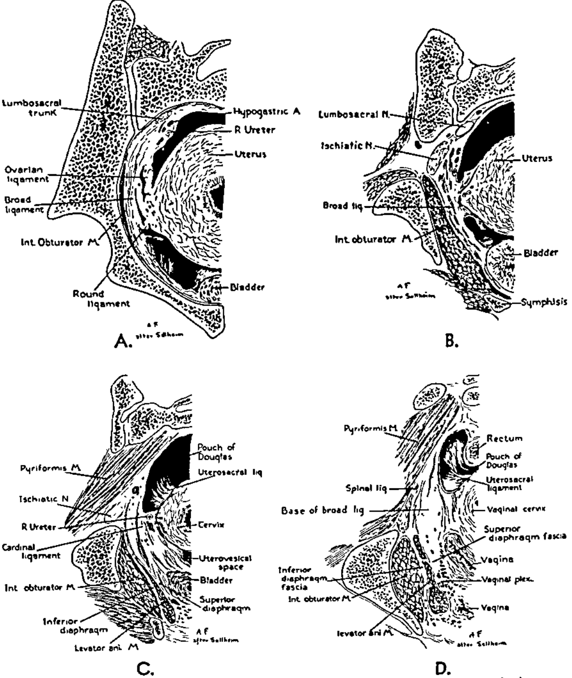


FIG. 7. Successive cross sections of the uterovaginal supports. (After Sellheim.) Upper left: A, cross section at about the first sacral vertebra, showing the broad ligament and its relation to the obturator internus muscle, etc. Upper right: B, cross section 2 cm. below that in the preceding illustration, showing the broad ligament and its relation to the obturator internus muscle and the sheaths of the nerve trunks Lower left · C, cross section 2 cm. below that in the preceding illustration, showing the cardinal ligament and its relation to the piriform, internal obturator, and levator ani muscles, the sheaths of nerves, ureter, and blood vessels. Lower right: D, cross section 2 cm. below that in the preceding illustration, showing the base of the broad ligament and its relation to piriform and levator ani muscles, the spinal ligament, and uterosacral ligament. (Farrar, L. K. P.: *Surg., Gynec. & Obst.*, 1938.)

In the male the comparable ligamentous supports are of less clinical and surgical importance and an upper pelvic floor or diaphragm is rarely referred to.

The pelvic diaphragm is the more important stratus of the pelvic floor.

Relaxation of the pelvic diaphragm, particularly in the female, may result in functional disturbances of the rectum and sigmoid. The proctologic symptoms of incomplete and obstructive evacuation, false sense of defecation, prolapse, proctostasis etc., are commonly associated with rectocele, cystocele and displacements of the uterus and adnexa.

The Perineal Triangles

The perineum is commonly divided into anterior and posterior triangles by an interischial line passing just in front of the anus (fig. 8). The anterior triangles are the urogenital, genital or urethral triangles (not the urogenital diaphragm); the posterior triangles are the anal, ischial, ischiorectal or ischio-anal. The triangular areas corresponding to the skin surfaces are sometimes referred to as the anal or urethral perineum—the term perineum being used in its broader sense. It should be noted that the anal and urethral triangles embrace all the structures of the pelvic floor situated between the peritoneum and the skin. The essential components of these triangles are muscular strata separated by fascia disposed in layers of varying density.

The Anal Triangles

These contain the following musculature:

(1) the external and internal anal sphincter muscles
(2) the levator ani muscle } the pelvic diaphragm
(3) the coccygeus } the pelvic diaphragm
(4) the piriformis muscle

These muscles will receive separate description in Chapters III and IV.

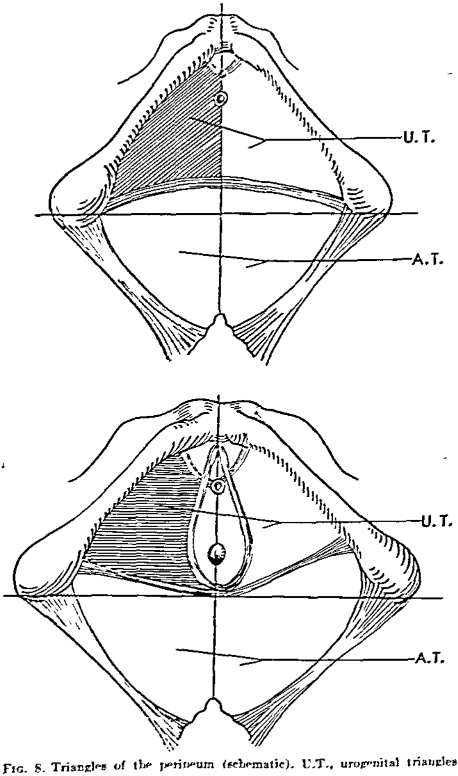


FIG. 8. Triangles of the perineum (schematic). U.T., urogenital triangles; A.T., anal triangles.

The Urogenital Triangles

The urogenital triangles contain three distinct muscle groups: a superficial and deep stratum of perineal muscles and the pubic portions of the pubococcygeus and puborectalis muscles (fig. 9). The perineal muscles are commonly referred to as occupying the superficial and deep perineal compartments or pouches.

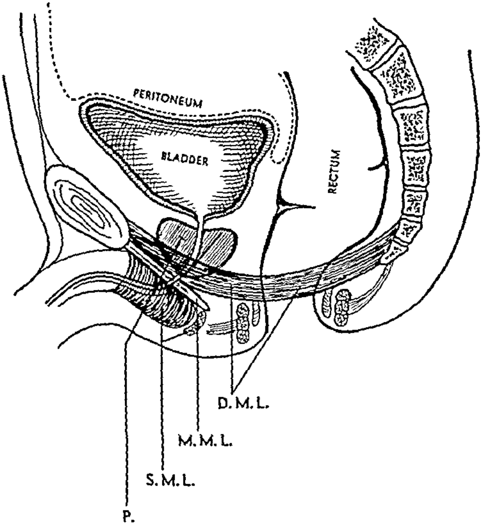


Fig. 9 The musculofascial layers of the urogenital triangle (male) D.M.L., levator ani muscle layer, M M L , deep perineal muscle layer; S.M.L., superficial perineal muscle layer; P , prostate gland

The superficial perineal compartment contains the following muscles:

(a) bulbocavernosus (sphincter vaginae, accelerator urinae, bulbospongiosus muscle)
(b) ischiocavernosus muscle
(c) *superficial transverse perineal muscle*

The deep compartment, also named the triangular ligament or urogenital diaphragm, contains the following muscles:

(a) The deep transverse perineal muscle
(b) *The sphincter urethra membranacea muscle*

The levator strata or deepest muscle layer is also referred to as the urogenital portion of the *pelvic* diaphragm, not the urogenital diaphragm.

The Superficial Pouch or Compartment

In the male this compartment is roughly 1½ to 2 cm. in depth. *It extends about 5 cm. along the pubo-ischial ramus corresponding* to the pubic attachment of Colles' fascia. It measures about 6 cm. along its posterior border, corresponding to the attachment of Colles' fascia along the posterior margin of the urogenital diaphragm. *The main layer of Colles' fascia forms its floor and the* lower layer of the urogenital diaphragm (inferior urogenital fascia) its roof (fig. 10).

Anteriorly it is continuous with the subcutaneous interval in the *abdominal* wall. *Posteriorly the intimate relation of Colles' fascia to* the superficial transverse perineal muscle and the posterior border of the urogenital diaphragm (triangular ligament) closes off the compartment from the perianal and ischiorectal spaces.

Urinary extravasation in the superficial compartment is hence more apt to extend anteriorly in the abdominal wall than posteriorly.

In the female, the superficial compartment has essentially the same boundaries and contains the structures homologous to that in the male. It is broader, deeper and less compact corresponding to



FIG. 10. The superficial perineal musculature (male). A, bulbocavernous muscle, B, ischiocavernosus muscle; C, superficial perineal pouch; D, triangular ligament; (E) anterior fibrous raphe; F, ischial tuberosity; G, Colles' fascia; H, external anal sphincter muscle; I, anal skin; J, ischiorectal fossa; K, gluteus muscle.

the increased width and depth of the pubic arch. Although its fascial layers have a very strong attachment laterally along the pubic rami they afford but little support medially due to the interposition of the vagina. The following muscles are found in the superficial perineal compartment.

The Bulbocavernosus Muscle

In the male the bulbocavernosus muscle, unpaired, extends from the central perineal tendon to the body of the penis (fig. 10). It arises mainly from the central tendinous raphe along the lateral and posterior aspect of the bulb. Its posterior fibers are somewhat broader and better developed and after covering and encircling the bulb they attach to the triangular ligament. The median fibers directed anteriorly completely encircle the corpus cavernosum urethrae and are attached to Buck's fascia which surrounds it, and which is continued over the crura and body of the penis. Its anterior fibers are somewhat more superficial and are in close relation to the adjacent ischiocavernosus muscle. They insert on the dorsal aspect of the penis.

Through its attachment to the triangular ligament by Buck's fascia and the tunica albuginea, both of which are continued over the penile portion of the penis, the contraction wave of the bulbocavernosus, extending anteriorly, empties the urethra. It compresses the bulb and assists in erection and ejaculation The *integrity of the triangular ligament is important to the proper* functioning of this muscle.

In the female this muscle is symmetrically disposed and surrounds the vagina (fig. 11). Although described as a sphincter, it actually has little sphincteric action. Its principal function, as in the male, is to compress the bulb and maintain turgescence of the corpora cavernosa. Its symmetrical halves are closely applied to the adjacent portions of the vestibular bulbs (erectile bodies) which surround the vaginal orifice. Posteriorly they insert, together with the small superficial transverse perineal muscles and the extensions of the superficialis sphincter ani externus, into the central

tendinous raphe of the perineal body. Anteriorly the fibers become indistinct and insert into the sides and dorsum of the body of the clitoris (fig. 12).

The bulbocavernosus in both sexes is supplied by small branches of the perineal arteries and nerves as they traverse the superficial perineal compartment.

In both sexes the bulbocavernosus muscle immediately surrounds the bulb. In the female this is represented by symmetrical venous plexuses, about 1 inch in length, situated just lateral to the vestibule below the labia minora. In the male the fused plexuses which surround the corpus cavernosum urethrae are projected posteriorly as the bulb which is firmly attached to the

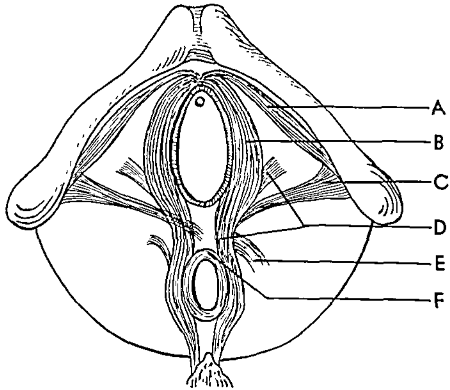


FIG. 11. The perineal muscles of the female (schematic). A, ischiocavernosus; B, bulbocavernosus; C, superficial transverse perineal muscle; D, superficialis portion of external sphincter ani; E, fibers of the profundus external sphincter; F, encircling fibers of the subcutaneous external sphincter ani.

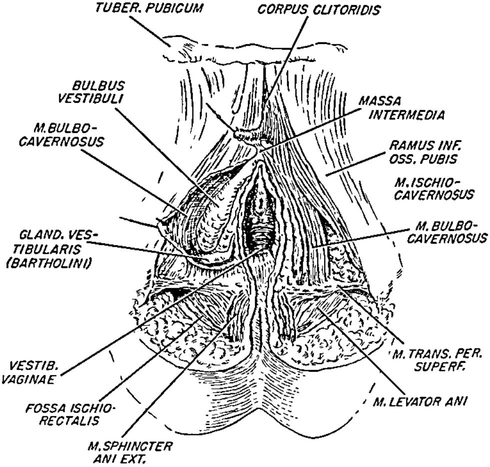


FIG. 12. The superficial perineal muscles in the female. (After Curtis). In the anal part of the perineum the levator ani and external anal sphincter muscles of each side are shown by removal of the superficial fatty tissue. In the urogenital part of the perineum, on the right side, by cutting away the muscle fascia, the ischiocavernosus, superficial transverse perineal, and bulbocavernosus muscles have been brought into view. On the left side the bulbocavernosus muscle has been reflected to expose the bulb of the vestibule and greater vestibular (Bartholin's) gland and duct. Anteriorly are seen the glans, body, and intermediate mass of the clitoris. Redrawn from Curtis, A. H., et al.: *Surg., Gynec. & Obst., 74:* 1942.

inferior layer of the urogenital diaphragm (triangular ligament). The bulb is an important landmark in perineal surgery.

The Ischiocavernosus Muscle (Erector Penis, Erector Clitoridis)

This muscle arises from the ischial ramus directly anterior to the superficial transverse perineal muscle. It extends along the

pubic ramus covered by the deep crural septum of Colles' fascia and inserts by a tendinous expansion into the crura of the penis or clitoris. In the male this muscle has a comparatively broad tendinous origin from the pubic ramus and partially overlies the perineal artery in the superficial perineal compartment.

In the female the muscle is comparatively much smaller, with poorly developed muscle fibers. It has a similar origin and inserts into the crura and body of the clitoris. It assists in erection of the penis (clitoris) and in ejaculation. It is supplied by the perineal artery and nerve.

The Superficial Transverse Perineal Muscle

This muscle develops in close relation to the external anal sphincter with which it is sometimes continuous, suggesting their common embryologic derivation (see page 54). It takes origin from the medial aspect of the pubo-ischial ramus just below and behind the ischiocavernosus muscle. Crossing the posterior portion of the superficial perineal compartment, covered by Colles' fascia it passes medially to join with its fellow of the opposite side, and inserts into the central perineal raphe or tendon. It marks the posterior limits of the superficial perineal compartment and is a guide to the interval between the rectum and vagina or prostate. Colles' fascia, fusing with the infra-anal fascia and the urogenital diaphragm overlies the posterior aspect of the superficial transverse perineal muscle.

In the female this muscle is distinctly smaller and ill defined, and is fibromuscular rather than muscular in character (fig. 12). It has essentially the same disposition as in the male. At the perineal junction its fibers, scarcely distinguishable, insert together with the deep transverse perineal muscle and the external anal sphincter into the perineal body.

The vulvovaginal glands (Bartholin) are situated behind and lateral to the bulbs near the junction of the superficial and deep compartments, where they are not normally palpable. In the male the homologous gland of Cowper lies in the deep compartment.

The origin of the superficial transverse perineal muscle from the ischial tuberosity in both sexes marks the point at which the superficial perineal branches from the pudendal nerve arise and where they are most accessible for local infiltration anesthesia.

The Deep Perineal Pouch or Compartment (Triangular Ligament or Urogenital Diaphragm)

The deep perineal compartment lies between two well defined fascial layers (the superior and inferior urogenital fasciae) which on account of their triangular shape in the male and their great tensile strength are commonly referred to as the triangular ligament, or urogenital diaphragm (fig. 13). It is about one-half to one centimeter in thickness, somewhat greater in the female. Laterally its fascial layers have a very firm attachment for approximately 5 cm. along the inner surfaces of the pubo-ischial rami. Its posterior margin is approximately seven centimeters in length , slightly greater in the female. Medially musculo-fascial extensions fuse into the fascial collars of the urethra, vagina and prostate.

In the male the triangular ligament contains between its layers the deep transverse perineal and sphincter urethrae membranaceae muscles, the small bulbourethral glands (Cowper), the pudendal vessels and nerves and the nerve to the penis (clitoris).

The deep transverse perineal muscle spans the posterior part of the trigone. Its flattened fibers arranged in strands arise from the lateral surfaces of the pubic rami and intermingle with fibers of the deep urethral sphincter muscle, inserting jointly into an ill-defined median tendinous raphe.

The sphincter of the membranous urethra consists also of muscular fibers which immediately surround the urethra. These fibers are continuous with the circular fibers of the prostatic urethra above and the membranous urethra below.

The two layers of the triangular ligament fuse anteriorly just behind the pubes to become continuous with the supra-anal fascia

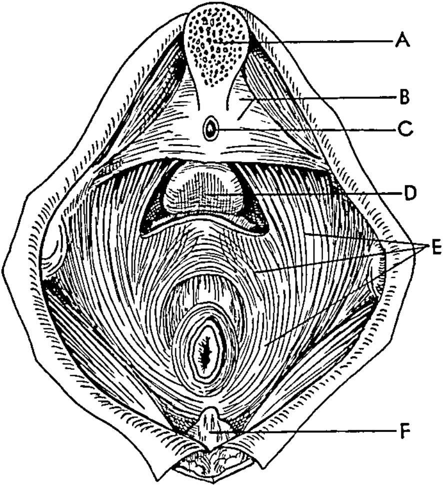


Fig. 13. Triangular ligament (male). Schematic drawing from dissection. The bulb has been dissected off the triangular ligament and retracted anteriorly between the ischiocavernosus muscles. The urethra has been cut across, exposing the entire posterior half of the triangular ligament. Behind the ligament and between the legs of the levator ani is the prostate gland. The levator ani fibers encircling the rectum anteriorly are well developed in this specimen. Note that the triangular ligament is but 1 to 1¼ inches on its triangular sides. In the female, it is composed of two lateral wings, somewhat wider and thicker than in the male. Compare with fig. 13. A, bulb; B, *triangular ligament;* C, urethra; D, prostate; E, levator ani; F, coccyx.

(parietal) of the pelvis and to form in this situation the small but firm transverse ligament of the pelvis, above which the dorsal vein and nerve of the penis (clitoris) continue to the prevesical space of Retzius.

In the female the increased width of the pubic arch and the larger vaginal canal with its potential requirements for expansion modify the structure of the triangular ligament. Anterior to the vagina the triangular ligament is comparatively strong and at this point it supports the urethral reflections from the levator ani muscle covered by the supra-anal fascia. Curtis refers to these wing-like reflections as the pubo-urethral ligaments, since after slinging around the urethra they insert into the pubic bone (fig. 110). Posterior to the urethra and anterior to the vaginal floor muscular fibers from the levator and the sphincter membranaceae muscles cross from one side to the other.

In the male the triangular ligament is commonly described as terminating anterior to the anal canal. In the female, however, according to Curtis, it does not terminate along a transverse line as usually described but is continued posteriorly surrounding the anal canal to finally reach a coccygeal attachment above the superficialis portion of the external anal sphincter muscle. The triangular ligament, therefore, in the female is quadrangular rather than triangular in form. A homologous posterior extension in the male has yet to be described (fig. 14).

Near its pubic attachment the triangular ligament fuses with the caudal reflections of the lateral wings of the vagina (fig. 14). In the expansion of the vagina during parturition the lateral wings of the triangular ligament swing forward and upward against the pubic rami, their lateral attachments acting as a sort of hinge.

Posterior to the vagina the supra-anal and infra-anal fascia, including the reflections from Colles' fascia, the inferior perineal fascia, the extensions from the anal sphincter muscles and the superficial perineal fascia, all combine to form the fascial components of the perineal body. Attenuation of the levator fascial

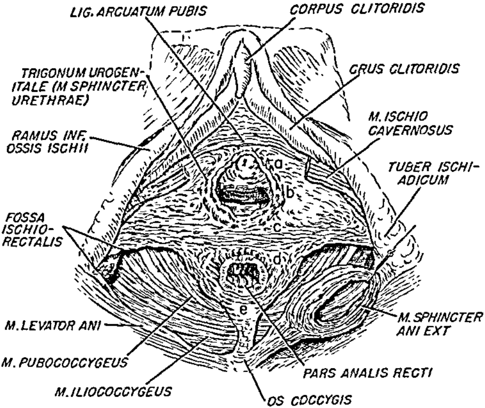


FIG. 14 The urogenital diaphragm (female). (After Curtis). In the anal triangle the external anal sphincter, now detached from the subjacent muscles of the urogenital and pelvic diaphragms and from the intrinsic musculature of the anal canal, has been drawn aside to reveal the backward-directed fibers of the urogenital diaphragm; the ischiocavernosus muscles have been rolled medialward away from the crura and the body of the clitoris; the superficial transverse perineal muscles have now been entirely removed to show the course of fibers at the base of the urogenital diaphragm. It is evident that the so called sphincter of the urethra sends muscle fibers not only into and in front of the urethra, at (a); but also into the vagina, (b); across the midline between the vagina and anus, (c); into the wall of the latter, (d); and backward to the coccyx, (e) Redrawn from Curtis, A H., et al. *Surg., Gynec. & Obst.*, *74:* 1942.

planes and separation of their related muscles increasing the width and length of the pelvic aperture predisposes the female to rectocele, cystocele and prolapse.

The derivation of the so-called layers of the triangular ligament is still somewhat equivocal and the ligament is considered by some

(parietal) of the pelvis and to form in this situation the small but firm transverse ligament of the pelvis, above which the dorsal vein and nerve of the penis (clitoris) continue to the prevesical space of Retzius.

In the female the increased width of the pubic arch and the larger vaginal canal with its potential requirements for expansion modify the structure of the triangular ligament. Anterior to the vagina the triangular ligament is comparatively strong and at this point it supports the urethral reflections from the levator ani muscle covered by the supra-anal fascia. Curtis refers to these wing-like reflections as the pubo-urethral ligaments, since after slinging around the urethra they insert into the pubic bone (fig. 110). Posterior to the urethra and anterior to the vaginal floor muscular fibers from the levator and the sphincter membranaceae muscles cross from one side to the other.

In the male the triangular ligament is commonly described as terminating anterior to the anal canal. In the female, however, according to Curtis, it does not terminate along a transverse line as usually described but is continued posteriorly surrounding the anal canal to finally reach a coccygeal attachment above the superficialis portion of the external anal sphincter muscle. The triangular ligament, therefore, in the female is quadrangular rather than triangular in form. A homologous posterior extension in the male has yet to be described (fig. 14).

Near its pubic attachment the triangular ligament fuses with the caudal reflections of the lateral wings of the vagina (fig. 14). In the expansion of the vagina during parturition the lateral wings of the triangular ligament swing forward and upward against the pubic rami, their lateral attachments acting as a sort of hinge.

Posterior to the vagina the supra-anal and infra-anal fascia, including the reflections from Colles' fascia, the inferior perineal fascia, the extensions from the anal sphincter muscles and the superficial perineal fascia, all combine to form the fascial components of the perineal body. Attenuation of the levator fascial

anatomists as merely a composite fasciomuscular structure without sharply defined layers as commonly described.

In the female the vagina is sometimes not considered as piercing the diaphragm as the urethra does.

The Levator Ani Stratum

This stratum of the urogenital triangles is formed by the partially superimposed crura of the pubococcygeus and puborectalis muscles which have a firm attachment to the deep layer of the triangular ligament. It forms the urogenital portion of the pelvic diaphragm, which is greatly strengthened by the triangular ligament as well as the superficial perineal muscles.

These three superimposed perineal musculofasical strata provide a strong support for the genito-urinary organs and their musculature, particularly so in the male where they form a continuous and composite diaphragm—spanning the pubic interval (fig. 15).

From the structural and functional standpoint the deep muscular strata are primarily supportive, accomodative and evacuatory while the superficial strata are essentially sphincteric. However, musculofascial extensions from the levator ani muscles synergize and co-ordinate the actions of the urogenital sphincters.

Pelvic Palpable Landmarks

In the digital examination of the rectum and vagina the following palpable landmarks are useful.

In the female: the pubic arch and symphysis, the urethra throughout almost its entire extent, the fascial arch of the fascia endopelvina, the important ischial spine, the sharp margin of the sacrospinous ligament, the ischial tuberosity and finally the lower margin of the sacrum and the entire coccyx, are usually readily identifiable.

In the male the comparable landmarks, excluding the symphysis and urethra, are readily palpable.



FIG. 15. The musculofascial layers of the urogenital triangle. (Dissection by author.) A, ischiocavernosus muscle; B, bulbocavernosus muscle; C, interval between ischiocavernosus and bulbocavernosus muscle; D, the superficial transverse perineal muscle; E, central tendinous point of the perineum; F, triangular ligament; G, fascial shelf; H, prostate gland; I, levator ani muscle; J, rectum.

CHAPTER II

The Anal Canal

The Development of the Anorectal Junction

The development of the anal canal and rectum with their subsequent continuity in man is characterized by an interpenetration of the epithelial, glandular and muscular embryonic anlages. This overlapping and transition persist in the adult anatomy and are significant in the pathogenesis and surgery of anorectal disease. The following embryologic considerations are presented to assist in clarifying the more important anatomic details peculiar to the anal canal and rectum.

The development of the anorectal junction is of particular proctologic significance and will be described in detail.

The anal canal develops in the ventral aspect of the cloacal membrane overlying the post-allantoic gut—not the hindgut. Its early development is observed as an invagination of the ectoderm—called the proctodeum—which becomes a recessed and constricted portion of the larger cloacal membrane (fig. 16). This proctodeal depression becomes encircled by a developing ridge of anal musculature and the fusion of the mesially directed anal tubercles. As further umbilication occurs, the newly formed anal canal is separated from the primitive rectum only by an irregular interdigitating membrane—the anal membrane or the proctodeal plate—which is lined by entoderm above and ectoderm below (fig. 17). With the dissolution of this membrane the anorectal junction is completed (fig. 18).

Simultaneously with the development of the proctodeal in-

The extent to which suppurative and malignant processes obliterate these structures may be significant to their diagnosis and treatment.

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Simultaneously with the development of the proctodeal in-

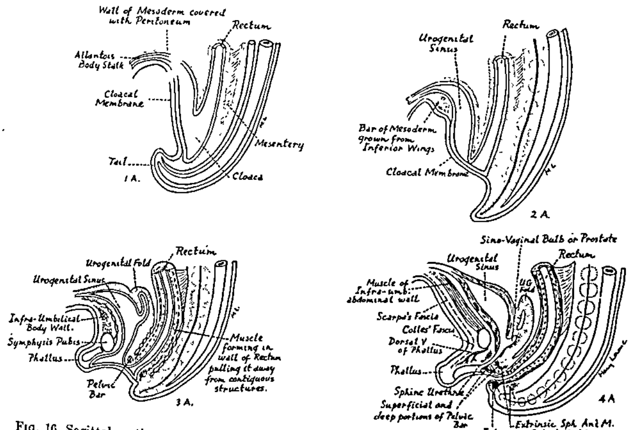


FIG. 16. Sagittal section of the caudal embryo. Note the separation of the common cloaca by the urogenital septum or pelvic bar, to form the urogenital sinus anteriorly and the rectum posteriorly. 3.A, the anorectal cloacal region just before the absorption of the anal membrane, which is complete in 4.A. (Levy, E.: *Am. J. Surg.*, 1930.)



FIG. 17. Longitudinal section through anorectal junction, in 32-mm. (approx.) human embryo (McNee). Section shows the anal epithelium capped by the rectal epithelium, the external sphincter overlapping the internal sphincter, and the levator ani muscle (×100). A, levator ani; B, internal sphincter; C, rectum; D, anal membrane; E, external sphincter; F, anal canal (Harris, H. A.: *Proc. Roy. Soc. Med.*, 1929.)



FIG. 18. The anorectal junction (embryo 80 mm.).

vagination and absorption of the proctodeal plate the primitive rectal ampulla or bulbus analis of the post-allantoic gut accomodates itself to the smaller terminal rectum—the bulbus terminalis—(Johnson) by forming a series of longitudinal folds somewhat in the manner of a purse-string. These folds form the columns of Morgagni which extend upward from the anorectal line through the pars analis recti into the rectal ampulla.

As the internal sphincter develops and telescopes itself through the external sphincter, the adjacent epithelial surfaces override. The anal or proctodeal membrane is absorbed and the ectodermal ridge becomes continuous or over-rides the rectal columns of Morgagni. As Harris tersely puts it: "the anorectal junction is not a clearly demarcated line with columnar epithelium above and squamous epithelium below, as in the rat, but is an irregular zone in which proximodistally columnar epithelium gives way to irregular zones of alternating squamous and columnar epithelium, finally resulting in the squamous epithelium of the anal canal" (fig. 19).

The anal valves represent ectodermal folds or pleats from the constricting anal or proctodeal membrane, bridging the interval between adjacent rectal columns. The interval or free space behind the valves is the crypt of Morgagni. The unbridged interval between the rectal columns is the rectal sinus of Morgagni. The crypts then appear to be the result of a structural accommodation and, as observed by C. Naunton Morgan, the angle at which the post-alantoic gut is pierced by the proctodeum accounts for the deeper crypts and sinuses of Morgagni persisting in the posterior half of the anal canal.

The irregular development of the anorectal junction just described accounts for the variety of descriptions regarding the type of epithelium found in the anal canal or rectum.

Small islands of squamous epithelium are regularly observed in histologic sections of the anorectal line, extending above the columnar epithelium of the rectum proper. This overlapping may be anticipated in the 32-mm. embryo (fig. 17). In adult specimens,



FIG. 18. The anorectal junction (embryo 80 mm.)

midway between the ischial tuberosities (fig. 20). It is situated from 1 to 2 inches anterior to the tip of the coccyx, somewhat more anteriorly in the female. The skin immediately surrounding the anus is usually pigmented and rugous to accommodate the varying tone of the subcutaneous external sphincter muscle, which is the only muscle surrounding the anal orifice.

The perianal region contains the usual glandular elements of skin, including the special circumanal glands of Gay, the apocrine and eccrine glands, in which perianal hydradinoma develop.

These glandular elements are gradually lost in the transitional squamous epithelial lining of the anal canal proper (the anoderm) which terminates at the anorectal line. The anus varies from 5 to 9 cm. in circumference but admits of wide variations. It may be congenitally small, irregular, deformed or patulous from previous surgery or pathology. In heavy and muscular individuals the anus may be deeply placed between the buttocks and is referred to as funnel-shaped.

In the resting state, the anus presents a groove-like appearance, the adjacent perianal skin being in opposition. This predisposes it to moisture and intertriginous irritation. In the active state, the anus and anal canal accommodate themselves to the consistency of the feces which, when sufficiently soft, may be molded by the anal musculature but when firm may distend and rupture the anal epithelium (anoderm).

The Anal Canal and Its Lining

The anal canal is a musculomembranous passage joining the anus and the rectum. Its surrounding muscular walls have a trilaminary arrangement of particular surgico-pathologic significance, which will be described later in detail (see Chapter III, Anorectal Musculature).

The anal canal extends from an arbitrary point at the anal verge to the level of the anorectal (dentate etc.) line. It is covered by modified squamous or transitional epithelium which contains but few sweat glands or hair follicles. The squamous epithelial lining

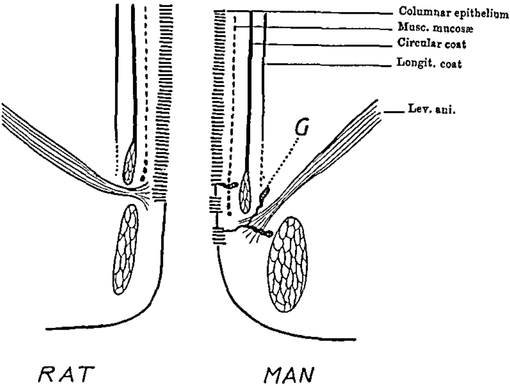


FIG 19. Diagrammatic representation of relationship of epithelia and muscles at the level of the "white line" in the rat and in man. The possible extensions of the deep rectal glands are shown. (Harris, H. A.: *Proc. Roy. Soc. Med.*, 1929.)

where trauma and chronic infection inherent to this region produce a proliferation of the squamous epithelium, the overlapping is usually pathologic and has been referred to by Krafka as "creeping epithelium."

As in the cervix uteri, it is not uncommon to observe chronic hemorrhoids covered with an aberrant growth of squamous epithelium.

This squamous metaplasia may be of some etiological significance in anorectal epitheliomata.

THE ANUS

The anus merely refers to the external opening of the anal canal, presenting itself normally as an anteroposterior slit placed

thins out and ends somewhat abruptly at the anorectal line, but some overriding of adjacent epithelial surfaces is common. This transitional skin of the anal canal may be conveniently called the anoderm (Gorsch). It is smooth, gray in color, poorly vascularized and highly sensitive. It is sometimes referred to as mucocutaneous or as the anal mucosa. There are, however, normally only traces of mucous membrane in the anal canal (fig. 21).

Milligan and Morgan, however, describe the anal canal as extending to the level of the anorectal *muscle ring*. In this case the mucous membrane and its cuboidal epithelium covering the internal hemorrhoidal plexus from the level of the anorectal *muscle ring* to the anorectal line would be considered the upper third of the anal canal and covered by mucous membrane[1] (figs. 22 and 23).

The conjoined longitudinal muscle is firmly attached to the anal canal lining between the upper border of the subcutaneous external sphincter muscle and the lower margin of the internal sphincter muscle and forms the so called intermuscular septum (intersphincteric line etc.) (p. 78).

This intermuscular interval is the most important landmark in the anal canal. It is readily defined on palpation and affords a constant and precise level of orientation for the anorectal musculature. Between it and the anorectal line above is the narrow but important upper zone of the anal canal, commonly referred to as the *pecten*.

Terminal fibro-elastic extensions of the conjoined longitudinal muscle, after encircling the lower margin of the internal sphincter muscle, also gain a firm insertion into the pecten *above* the intersphincteric line and become continuous with the muscularis mucosae of the submucous space. These extensions tend to fix the pecten and form an important component in the support of

[1] This concept, although practical, would of necessity include the internal hemorrhoidal plexus, its venous, arterial and lymphatic supply as part of the anal canal. For teaching purposes we have found it simpler to consider the anorectal line as the upper end of the anal canal, and it will be so considered in this volume.



Fig. 20. The anus.

the internal hemorrhoidal annulus. They also form a part of the "musculus submucosa ani" (p. 79).

In its inactive state the walls of the anal canal are in more or less opposition from side to side, owing largely to the tonic state of its musculature, the internal sphincter sometimes being most prominent in this activity. In length it varies from 2 to 5 cm., and in circumference from 5 to 9 cm., admitting of wide variations.

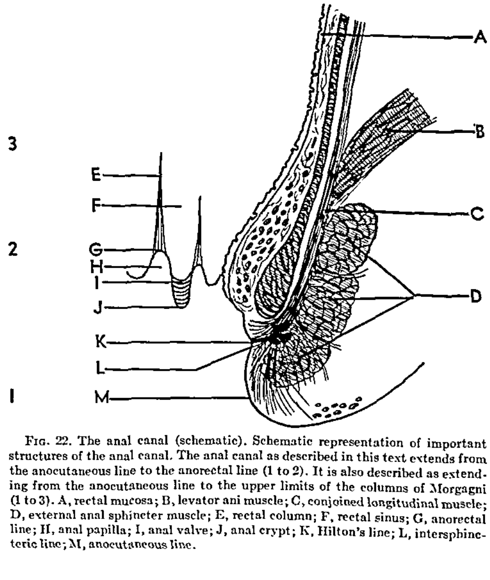


FIG. 22. The anal canal (schematic). Schematic representation of important structures of the anal canal. The anal canal as described in this text extends from the anocutaneous line to the anorectal line (1 to 2). It is also described as extending from the anocutaneous line to the upper limits of the columns of Morgagni (1 to 3). A, rectal mucosa; B, levator ani muscle; C, conjoined longitudinal muscle; D, external anal sphincter muscle; E, rectal column; F, rectal sinus; G, anorectal line; H, anal papilla; I, anal valve; J, anal crypt; K, Hilton's line; L, intersphincteric line; M, anocutaneous line.



FIG. 21. Photomicrograph of longitudinal section through the anorectal junction in a female, aged 30. The rather abrupt change from the cuboidal or columnar epithelial glands of the rectum to the irregular cornified or squamous epithelium of the anal canal is well marked. A, anal skin (anoderm); B, muscularis mucosa; C to D, transitional zone; E, rectal mucosa.

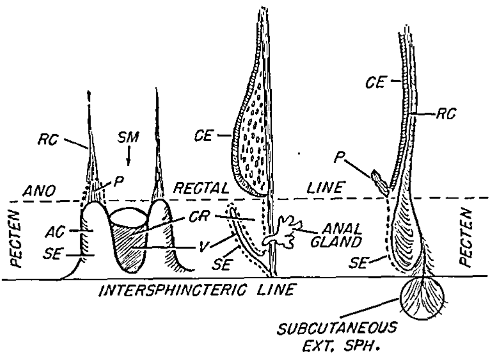


Fig. 24. Anterior and lateral views of the anorectal line (schematic). Note that the columnar epithelum of the rectum may extend into the depth of the anal crypt and that the squamous epithelium of the pecten may extend from the anal column over the rectal column. R.C., rectal column; A.C., anal column; C.E., columnar epithelium; S.E., squamous epithelium; P., papilla; Cr., crypt; V., valve; S.M., sinus of Morgagni.

first decade. In the second decade growth is again comparatively rapid and the anal canal reaches its adult proportions about the twentieth year. At birth the anal canal will normally admit an average-size index finger without rupture.

The Anorectal Line

There is considerable looseness in the anatomic descriptions as well as in the terminology of the anorectal line and its marginal structures, the crypts, anal valves, rectal columns, anal columns, papillae, etc. (fig. 24).[2] The anorectal line (dentate, pectinate,

[2] Not to be confused with the anorectal muscle ring.

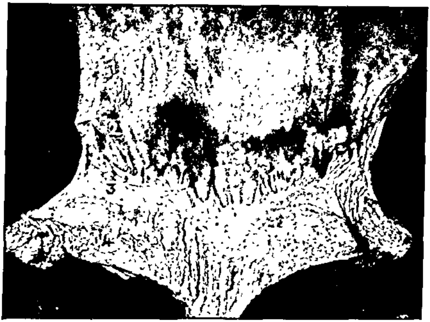


FIG. 23. Anal canal and rectum opened from behind. The four linings are shown. 1, rectal mucosa; 2, "anal mucosa"; 3, skin of the anal canal-anoderm; 4, skin of anus. (E. T. C. Milligan: *Proc. Roy. Soc. Med.*, May 1943.) Note that Milligan considers the terminal rectum covered by (2) anal mucosa. The author has called the skin of the anal canal (3) the anoderm and he considers the anorectal line as the upper limit of the anal canal

The axis of the anal canal is directed toward the umbilicus in comparison to that of the rectum which is directed toward the sacral promontory. These axial changes in the adult, somewhat acute, are formed by the puborectalis sling muscle, and they afford a directional support for the rectum and are important in the continence of the anal canal. This anatomic conformation in the female predisposes to rectocele, cystocele and fissure in ano.

In infancy and childhood, the axis of the anal canal corresponds more to that of the rectum which, lacking the adult curve, predisposes to rectal prolapse.

The length of the anal canal at birth is about 2 cm. posteriorly and slightly less anteriorly. By the end of the second year it has increased about one-fourth to one-third of its original length. After the second year growth is much slower up to the end of the

Between the columns of Morgagni are the so-called sinuses of Morgagni, or rectal sinuses, which are again confused with the crypts of Morgagni. The sinuses are usually directly continuous with the crypts (fig. 24).

The Anal Crypts (Anal Pockets, Sinuses, Saccules of Horner, Etc.)

As already noted, the anal cyrpts are tiny recesses between adjacent *anal* columns and behind the valves (fig. 24). There is considerable variation in the number, depth and shape of these crypts. The more constant and larger crypts are usually found just laterad to the posterior commissure and they are regularly described as an etiologic factor in anal fistula and fissure. The blind end of the crypts extends into the pecten and the cephalic open ends are directed upward toward the rectum continuous with the sinuses of Morgagni. Pathologic extensions from their caudal end may form anal sinuses which may include the crypt itself after closure of its cephalic end, preventing drainage (fig. 24).

The crypts are sometimes confused with the intramuscular glands and the preformed anal ducts.

The function of the crypts is not definitely understood. A lubricating role in defecation has been commonly ascribed to them, although mucus does not appear to be very readily expressed from them. Their significance in the etiology of anorectal suppuration, anal pruritus, etc., and their surgical therapeusis has been much overdone.

The terms "crypts" and "valves," separate structures, are frequently used interchangeably in the literature.

The Anal Valves

With no valvular function, the so-called anal valves (semilunar valves, etc.) are folds of squamous epithelium bridging adjacent anal columns from the free inner wall of the anal crypts. Histologically the valves are thickened or cornified epidermis

valvular, papillary, crypt line, linea sinuosa, etc.) merely marks the upper irregular margin of the pecten.

Current anatomic descriptions stress the presence of anal papillae as characteristic of the anorectal line. This is not in strict accord with the anatomic facts and, as already noted, papillae are more often absent than present. They do not arise from the free edges of the anal valves or crypts. It may be emphasized that the papillae when present correspond to the ectodermal projections, the anal columns, into the primitive rectum. These are continuous with the rectal columns of Morgagni. The tips of the anal columns frequently project above the lower margin of the rectal columns and, assuming a papillary-like form, are referred to as anal papillae. In chronic anal or rectal infections the papillae may be unusually prominent or hypertrophied, prolapsing through the anal canal.

The anorectal line is occasionally ill-defined due to retarded development, pathologic changes or previous surgery. These are of particular significance in the injection treatment of internal hemorrhoids.

The anorectal line may at times be observed at or near the anal verge, an indication of anal or mucous membrane prolapse.

The Columns of Morgagni (Rectal Columns)

A number of mucosal longitudinal folds formed in the bulbus analis of the primitive rectum persist as the rectal columns, or columns of Morgagni, which probably represent structures of accommodation for the contraction and dilatation of the anal canal and the sphincteric portion of the rectum.

Histologically these folds contain a somewhat denser muscularis mucosae, with a richer lymphatic, vascular and nerve supply than that of the adjacent intervening rectal wall. Somewhat more prominent at their junction with the anal columns, they extend to varying distances from one-half to one inch or more into the ampulla of the rectum where they gradually flatten out and merge insensibly into the surrounding mucosa.



Fig. 25. The pecten The Allis clamps have retracted the cornified transitional lining of the anal canal (anoderm) which has been freed by incising the fibro-elastic extensions of the longitudinal muscle. This exposes the tissues underlying the pecten of the anal canal as well as the perianal space. Small venous pools may be observed just below the internal anal sphincter. A, external anal sphincter; B, internal anal sphincter; C, fibro-elastic extensions of the longitudinal muscle; D, venous pools; E, skin margin; F, fossa navicularis; G, vagina.

which becomes continuous with the rectal cuboidal epithelium projected caudally between the anal columns into the blind end of the crypts (fig. 24). The squamous epithelium may be projected up and over the rectal columns as already noted.

The free borders of the valves, extremely variable, usually present a scalloped-edged appearance (semilunar) and their lateral margins are confluent with the anal columns, with which they usually correspond numerically (6 to 12).

The Pecten

The term pecten was originally introduced by Stroud in 1896 to describe the modified skin of the anal canal—its junction with the rectal mucosa resembling a comb or pecten.

The pecten is now generally considered as the upper third of the anal canal covered by the anoderm and extending from the intersphincteric line (intermuscular septum) below to the anorectal line or dentate line above. It varies from 5 to 15 mm. in length. It is an area of transition (fig. 25).

Clinically the pecten may well be considered as not only the anoderm of the anal canal but also as including its subepithelial *areolar and connective tissue which is continuous with the submucosa* of the terminal rectum. This tissue may contain the preformed intramuscular glands and ducts which may drain into the anal crypts, the anal canal, or rarely into the rectum. Occasionally the intramuscular glands have no drainage ducts. It is this subepithelial tissue of the pecten with its glands, lymphatics and communicating veins which is of considerable importance in anorectal infectious processes and their sequelae. The crypts are regularly overemphasized. Pectenosis, pectenitis and the pecten band are usually erroneously referred to as a cryptitis.

From the vascular point of view the pecten is significant in that it marks the anastomotic zone between the superior and inferior hemorrhoidal plexuses and, to a less extent, the middle hemorrhoidal vessels. The anastomosis is usually called abrupt. Actually



FIG 25. The pecten The Allis clamps have retracted the cornified transitional lining of the anal canal (anoderm) which has been freed by incising the fibro-elastic extensions of the longitudinal muscle. This exposes the tissues underlying the pecten of the anal canal as well as the perianal space. Small venous pools may be observed just below the internal anal sphincter. A, external anal sphincter; B, internal anal sphincter; C, fibro-elastic extensions of the longitudinal muscle; D, venous pools; E, skin margin; F, fossa navicularis; G, vagina.

the demarcation between these veins is not as abrupt as commonly described, particularly in hemorrhoidal disease. The pecten's vascular anastomosis drains freely to either portal or systemic systems.

From the lymphatic standpoint the pecten is also commonly referred to as the dividing line between the somatic and visceral chains. The lymphatics of this region are not well understood and it would appear from clinical observation that there are, in general, three common afferent pathways extending either from the epithelium of the pecten or its subjacent fibromuscular tissues, namely: 1) to the cutaneous and subcutaneous perianal network reaching the inguinal chain; 2) to the network following the inferior hemorrhoidal vessels; 3) to the plexuses following the branches of the superior hemorrhoidal vessels, particularly prominent in the rectal columns of Morgagni.

The lymphatic drainage is of considerable importance in the routes of extension followed by suppurative and malignant processes (see p. 263).

The pecten further marks a partial change in the nerve supply from the cerebrospinal of the anal canal to the sympathetic of the rectum proper (see p. 285).

The pecten is also of clinical importance because it is the narrowest portion of the anal canal; it is the most common site of acquired and congenital stricture or stenosis of the anal canal. Its lower margin, the intermuscular septum, is the common level through which suppurative processes extend laterally to the perianal and ischiorectal spaces and it is the usual location of the internal opening of the low-level anal fistula.

The pecten is finally the site of predeliction for anal fibrosis or pectenosis, the common pathogenic anlage, particularly for anal fissure.

It may be useful to note again here that terminal fibro-elastic extensions of the conjoined longitudinal muscle extend through the pecten and contribute to the formation of the so-called "musculus submucosae analis."

The pecten should not be confused with the pectinate, dentate, anorectal line nor with the "pecten band"—a controversial pathological condition. See Anorectal Line (p. 37), and "Musculus Submucosae Ani" (p. 79).

The Anal Intramuscular Glands, Anal Glands, Perianal Glands, Etc.

In the development of the anorectal junction, the anorectal or deep rectal or intramuscular glands are of particular protologic significance. These glands are commonly confused with the crypts of Morgagni or the normal mucous glands, or crypts of Lieberkühn, of the rectal mucosa. They are independent structures and their intramuscular location is dependent on the embryonic process of epithelial occlusion and canalization which is common to the entire gastrointestinal tract. The formation of the anorectal glands takes place before the process of epithelial occlusion and canalization is completed and before the muscularis mucosae is completely formed. There are, therefore, glands in the anlages of the muscular layers and these are regularly referred to by the embryologists as the deep intramuscular glands which are also common to the esophagus and duodenum.

Harris states that "such glands in post-natal life penetrate in turn the muscularis mucosae and may ramify to the internal sphincter, the external longitudinal muscle or even to the levator ani." The embryologists regularly describe the prominent occurrence of mucous and apocrine glands at all mucocutaneous junctions and emphasize the possibilities for pathologic hyperactivity and regression in these locations.

These glands or glandular elements and their ducts have been carefully described in the subepithelial and muscular strata of the anal canal and lower rectum by Johnson. (fig. 26). There is considerable confusion in the literature concerning their exact anatomic and histologic status.

Identical structures, in toto or in part, have apparently been

the demarcation between these veins is not as abrupt as commonly described, particularly in hemorrhoidal disease. The pecten's vascular anastomosis drains freely to either portal or systemic systems.

From the lymphatic standpoint the pecten is also commonly referred to as the dividing line between the somatic and visceral chains. The lymphatics of this region are not well understood and it would appear from clinical observation that there are, in general, three common afferent pathways extending either from the epithelium of the pecten or its subjacent fibromuscular tissues, namely: 1) to the cutaneous and subcutaneous perianal network reaching the inguinal chain; 2) to the network following the inferior hemorrhoidal vessels; 3) to the plexuses following the branches of the superior hemorrhoidal vessels, particularly prominent in the rectal columns of Morgagni.

The lymphatic drainage is of considerable importance in the routes of extension followed by suppurative and malignant processes (see p. 263).

The pecten further marks a partial change in the nerve supply from the cerebrospinal of the anal canal to the sympathetic of the rectum proper (see p. 285).

The pecten is also of clinical importance because it is the narrowest portion of the anal canal; it is the most common site of acquired and congenital stricture or stenosis of the anal canal. Its lower margin, the intermuscular septum, is the common level through which suppurative processes extend laterally to the perianal and ischiorectal spaces and it is the usual location of the internal opening of the low-level anal fistula.

The pecten is finally the site of predeliction for anal fibrosis or pectenosis, the common pathogenic anlage, particularly for anal fissure.

It may be useful to note again here that terminal fibro-elastic extensions of the conjoined longitudinal muscle extend through the pecten and contribute to the formation of the so-called "musculus submucosae analis."

enumerated. They have been overshadowed by the emphasis placed on the crypts in the literature.

According to Coleman, cited by Nesselrod, Chiari originally described the anal ducts and glands in 1878.

The significance of these glands was apparently overlooked until 1933, when Cuthbert Dukes confirmed their histology, and when in 1934 C. Gordon Watson emphasized their etiologic relation to anorectal abscess and fistula.

The histologic investigations of Tucker and Helwig, Hill, Pope and others seems to prove conclusively that these glands in the adult are preformed structures and play a significant role in anorectal suppuration, and that the crypt itself is "never the seat of an infection" and not the precise site of bacterial invasion.

From our meager histologic and embryologic investigations we consider the intramuscular glands as the only true preformed glands of the anorectal region and the ones commonly described as the preformed ducts (fig. 27). They vary in their histologic appearance and probably represent vestigeal hedonic glands related to sexual function in lower animals but undergoing regression in man. It is not unlikely that portions of these glands, commonly the main duct, emptying into the recesses of the crypts of Morgagni or branching or terminal acini have been variously described as isolated and different structures. Their pathologic significance, in contrast to the true crypts of Morgagni, stems from their intramuscular location and their predilection to a "closed" infectious process from the bowel with its common extensions into the perianal or perirectal spaces.

Of minor importance, but mentioned here to avoid confusion, are the remnants of epithelial occlusion cysts which, although more commonly found in the rectum proper, may invade the junctional tissues (fig. 28).

Additional small cysts lined by squamous epithelium are occasionally found in relation to the crypts and probably result from irregular absorption of the anal membrane. Both of these cysts are of little clinical significance.



Fig. 26. Reconstruction of epithelium of pars analis recti in 240-mm. embryo. (After Johnson.) Upper right: slender extension from each side of epithelial tube is an intramuscular gland; center: branched intramuscular gland of 245-mm. embryo; a., acinous termination; br., branch; amp., ampulla; ep.w., epithelial wall.

referred to by the same terminology which includes anal sinuses, diverticula, anal crypts, acinous glands, sinuses of the mucosa, preformed anal glands and ducts, etc. Repetition in the proctologic literature has surpassed histologic investigations and in the present state of our anatomic knowledge it seems scarcely possible definitely and accurately to clarify these terms and structures. Further careful histologic studies are apparently necessary.

It appears that the simple deep glands of the anorectal region, the intramuscular glands, described by Herman and Desfosses in 1880 and regularly mentioned by the embryologists since, have been grossly or in part described by a variety of terms as above

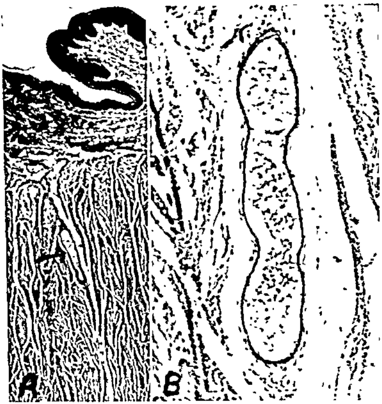


FIG. 28. Cyst formation in anal gland. A, location of cyst in internal sphincter (hematoxylin and eosin stain, ×19); B, enlarged view of cyst (Krajian carbol-fuchsin stain for mucin, ×110) (After Hill.)

but are active during life. Their exact function is as yet unknown but their role in the etiology of perianal infections is again emphasized by these authors.

The secretory activity of the anal glands is probably greater during adult life when endocrine and enzymatic influences on all glandular structures are greatest. This may account for the comparatively higher incidence of infectious processes in the third and fourth decades. The glands are already well developed at birth (fig. 29).

Nesselrod and his co-workers have also recently emphasized the role of these glands and ducts in the pathogenesis of the commoner anorectal infectious processes, and "in the interest of



FIG. 27. Right: intramuscular gland, new-born; Left: its cuboidal epithelial lining.

In addition to the true glands and the occasional developmental cysts just described there are pathologic extensions into the pecten which have also led to confusion, e.g., epithelized fistulae (Bartholdy), pulsion diverticula (Meisel), cysts of Physick, etc.; these should not be confused with true anatomic preformed structures.

Kratzer et al. have recently completed a rather extensive histological study of the perianal glands and ducts. They re-emphasize the etiological significance of these glands in perianal suppuration. About 24 per cent of the ducts and glands observed revealed a focal or diffuse periductal inflammatory reaction which reached as high as 89 per cent in what they considered an associated "cryptitis."

Hill and his co-workers conclude from their histologic investigations that these glands are probably not vestigeal structures

prevention of further anal infection" have advised a "prophylactic multiple cryptotomy."

It may be emphasized that "cryptotomy," if and when indicated, should adequately drain the pecten tissues with its infected glands and ducts.

Scarborough has reported a case of carcinoma apparently arising in a perianal gland.

Burke and his co-workers have also confirmed the presence of the anal glands throughout life and their pathogenic significance to anorectal infections. They likewise report an additional case of carcinoma arising in an anal gland.

Pathoanatomical Considerations

The pathologic misconceptions and the importance attributed to so-called "cryptitis" and papillitis in anorectal infectious processes, particularly fistulae, are deserving of some comment and appear to require re-evaluation.

"Cryptitis" is commonly considered an inflammation of the crypt which constitutes the primary source of infection in the commoner anorectal infectious processes.

However, Milligan, Hellwig and Tucker, Pope and others have demonstrated quite conclusively that the crypt itself is seldom the source of an infectious process.

Bacteria no doubt reach the pecten area and the anal ducts through the recesses of the crypts but the inflammatory reaction of the epithelium of the crypt itself, if any, is of minor importance as compared to that in the ducts, glands, lymphatics and areolar tissues of the pecten. The role of the crypts as a source of focal infection has been greatly overemphasized.

Bizarre anorectal symptoms, frequently neurogenic and without adequate pathologic basis, are much too often ascribed to cryptitis and papillitis and mistreated accordingly.

Fistulous termination of a perianal abscess arising from an anal focus, despite adequate surgical drainage, results primarily from the persistence of an "epithelial" focus in the perianal glands,



FIG. 29. Longitudinal section of the anorectal junction in a newborn male. Note the irregularity and the change from the rectal glands and solitary lymph follicle to the squamous epithelium of the anal canal. Note also the preformed ducts which are lined by a distinctive epithelium, *not* squamous. A, epithelium; B, glands of Lieberkühn and solitary lymph follicle; C, anal crypts; D, cornified squamous epithelium; E, anal ducts.

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ducts or areolar tissue and not the crypts. Persistence of this focus may likewise be the cause of fistula recurrence.

Endocrine and enzymatic "factors" in the perianal glands and their adjacent tissues are probably of more significance in bacterial and viral activity than is generally appreciated. Furthermore, embryologically the perianal, as well as the periurethral, periprostatic and perivaginal glands develop from the common cloacal membrane. Their similar susceptibility and response to common infectious processes is therefore significant.

Supports of the Anal Canal

In contrast to the rectum, the anal canal is fixed by its attachments anteriorly to the perineal body and posteriorly to the coccyx mainly through the coccygeal extensions of the superficialis portion of the external anal sphincter muscle. The levator plate, the ano-rectal muscle ring, the extensions and insertions of the conjoined longitudinal muscle and the continuity of the anoderm with the perianal skin are additional supportive factors. The important supportive function of the insertions of the conjoined longitudinal muscle may be destroyed in the so-called amputative or proctoplastic hemorrhoidectomies.

Relations of the Anal Canal

Anteriorly the anal canal is in direct and intimate relation with the perineal body and its musculo-fascial insertions. Its main relations laterally are the perianal and ischiorectal (anal) spaces, posteriorly the anococcygeal ligament and the superficial and deep postanal spaces.

Although considerably variable, the average measurements for the anal canal are:

	cm.
Anteriorly	1.5-2.5
Laterally	2 -3
Posteriorly	3 -4.5

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CHAPTER III

The Anorectal Musculature

EMBRYOLOGIC CONSIDERATIONS

It may be recalled that the caudal end of the embryo is covered by the cloacal membrane, on either side of which are situated the important lateral inferior wings of mesoderm from which there develop cephalically the infra-umbilical abdominal wall and caudally the external anal sphincter, the superficial urogenital musculature and the external genitalia.

As the lateral mesodermal wings reach the mid-line they form the genital folds, which develop into the labia or scrotum, and the genital or phallic tubercle, the potential penis or clitoris. Farther caudad the inner margins of the lateral mesodermal wings surround the entire cloaca, and form a ring of musculature, the important primitive sphincter cloacae muscle. There is as yet no distinction between anorectal and genito-urinary musculature. As development proceeds, however, the entire sphincter cloacae muscle becomes divided by a fusion of the anal tubercles across the perineal mid-line, forming the median perineal bar which separates the rectum from the urogenital structures and forms anteriorly a urogenital sphincter and posteriorly an anal sphincter. From the former develops all the musculature below the triangular ligament and from the latter the external anal sphincter. The trilaminar arrangement of the anal sphincter follows the general laminated arrangement of the perineal or urogenital musculature (fig. 30).

The embryologic development of the external anal sphincter

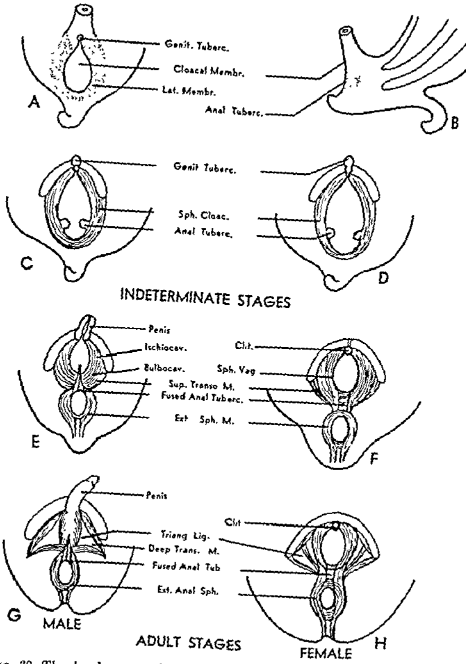


FIG. 30. The development of the perineal and anal musculature (schematic). A and B represent the earliest mesodermal anlages of the perineal structures. C and D are late indeterminate stages, showing the anal tubercles which fuse in the perineal midline to form an anterior urogenital and a posterior anal sphincter. E to H shows successive stages of sex differentiation with the corresponding perineal structures.

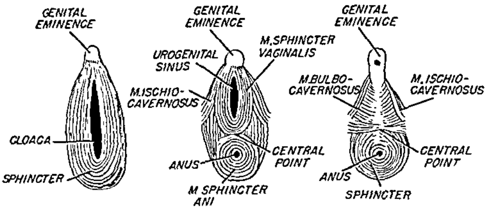


FIG. 31. Left: sphincter of the cloaca in the second month; center: muscles of the embryo at the beginning of the third month; right: muscles of the male embryo at the end of the third month. Redrawn from Keith, A.: *Human Embryology and Morphology*, Ed. 4. London: 1953.

musculature as a subdivision of the larger cloacal or urogenital sphincter readily explains the adult variations and the close continuity and overriding of the musculature of adjacent systems, as well as their similar vascular and nerve supply and their synergistic activities (fig. 31).

The development of the rectal musculature proceeds from a differentiation of the surrounding mesoderm into inner circular and outer longitudinal layers and a muscularis mucosae. At the anorectal junction these layers are projected into, and become enveloped by, the developing external anal cloacal sphincter. In the 30-mm. embryo it may be observed that the overlapping of the internal sphincter by the deeper portions of the external sphincter is already quite apparent, and foreshadows the telescoping arrangement in the adult (fig. 17, p. 27).

A similar telescoping arrangement is likewise shared by the rectal mucosa and adjoining skin and the interpenetration and irregular overriding of these contiguous surfaces account for the anorectal line (dentate, etc.) with its confusing alternating irregular zones of columnar and squamous epithelium, as already noted.

The levator ani muscle is formed from a separate anlage in

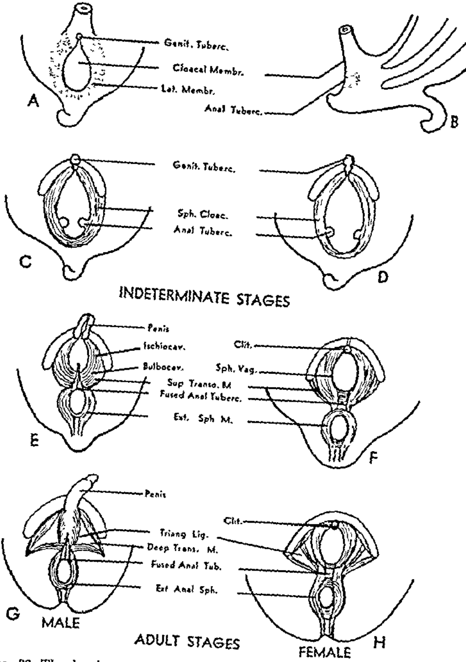


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in the female differs appreciably from that in the male and requires separate description.

Furthermore, the full surgico-pathogenic significance of the conjoined longitudinal muscle, particularly in its relation to the internal sphincter and the three divisions of the external sphincter muscle, has not received adequate proctologic consideration.

In this regard it may be noted that anatomic descriptions which divide the entire external sphincter ani into three separate divisions have been considered somewhat arbitrary and academic. With this we do not agree.

The External Anal Sphincter Muscle

Fairly accurate anatomic descriptions of this muscle were made as early as 1710 by Santorini who, so far as can be ascertained, was the first anatomist to present its true trilaminar arrangement. Subsequent important contributions were made by Cruveilhier (1843); Kohlrausch (1854); Béraud (1858); Rudinger (1873); Robin and Cadiat (1874); Roux (1881), and Laimer (1884).

In 1889 Holl offered the present tripartite nomenclature of subcutaneous, superficialis and deep portions which, although somewhat ambiguous, seems destined to have a permanent place in the proctologic literature, particularly through the recognition and use of this nomenclature by our esteemed British confreres, A. Lawrence Abel, E. T. C. Milligan, C. Naunton Morgan, William Gabriel, Peter Thompson and others.

In 1931 Hiller discussed the anal sphincter in relation to the etiology of anal fissure and fistulas. He described the anal sphincter as consisting "neither entirely of fibres encircling the anus nor of fibres extending anteroposteriorly, but a mixture of the latter type with fibres encircling the anus either anteriorly or posteriorly, in varying proportion."

In 1934 Milligan and C. Naunton Morgan described the trilaminar arrangement of the external anal sphincter and stressed

conjunction with the development of the pelvic bones and urogenital organs (see p. 115).

Preliminary Considerations

With but few exceptions the current literature on the anorectal musculature fails to offer adequate and complete descriptions, which are essential to full comprehension of the pathogenesis and surgical therapy of anorectal disease.

Variations in the anatomic arrangement of this musculature are common and repeated dissections emphasize the fact that there is no fixed anatomy (fig. 32). Moreover, the arrangement

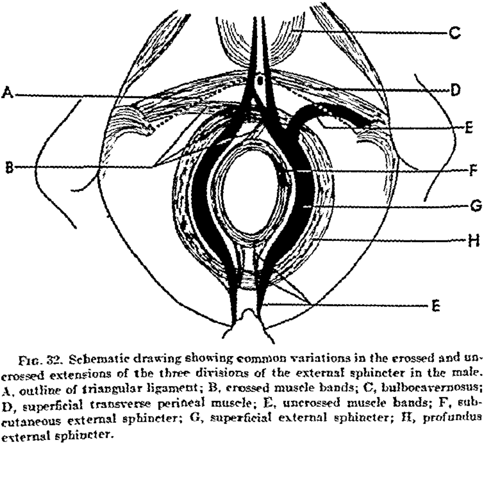


Fig. 32. Schematic drawing showing common variations in the crossed and uncrossed extensions of the three divisions of the external sphincter in the male. A, outline of triangular ligament; B, crossed muscle bands; C, bulbocavernosus; D, superficial transverse perineal muscle; E, uncrossed muscle bands; F, subcutaneous external sphincter; G, superficial external sphincter; H, profundus external sphincter.

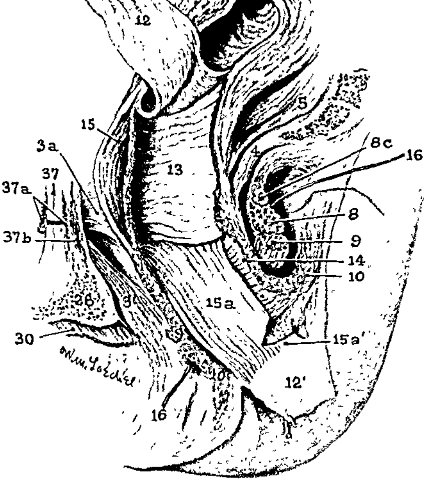


FIG 33. Rectal musculature. [Scale: 100% (1/1)]. Taken from right half of male pelvis. Seen from medial to lateral. Perineum from right pelvis, anal mucosa incised transversely at a level distal to rectal columns and valves of Morgagni; the two flaps (12 and 12') raised and reflected. Gorsch's postanal space (16) opened and continued forward between external sphincter and ischiorectal fat. 3', prerectal bundles of pubococcygeus, deep layer. 3 a, prerectal bundle of pubococcygeus, superficial layer. 4, fibrous plate from deep layer of pubo-anal muscle inserted into tip of coccyx. 5, aponeurotic plates of retrorectal muscles of pubococcygeus inserted into ventrum of coccyx. 8, puborectalis muscle (semitubular layer) with insertion into dorsum of coccyx. 8 c, puborectalis, cylindrical layer. 9, deep external sphincter ani. 10, superficial external sphincter ani. 12, anorectal mucosa, cranial flap. 12', anal mucosa, caudal flap. 13, circular musculature of rectum. 14, internal sphincter ani. 15, outer longitudinal musculature of rectal wall. 15 a, inner longitudinal muscle layer of anal canal (sustentator tunicae mucosa of Kohlrausch). 15 a', inner longitudinal muscle of anal canal, its insertion into skin. 16, ureteral catheter in Gorsch's postanal space and space between external sphincter ani and ischiorectal fat. 28, bulb of urethra. 30, right bulbocavernosus muscle. 37, membranous urethra. 37 a, external sphincter urethrae. 37 b, deep transverse perineal muscle. (From Uhlenhuth, E.: *Problems in the Anatomy of the Pelvis*, Philadelphia, Lippincott, 1953.)

both the anatomy of this muscle and the puborectalis in the surgery of anorectal fistulas.

In 1940 Edward Levy reviewed the ancient as well as the modern literature on the anorectal musculature. He described his own dissections in great detail and emphasized the importance of the conjoined longitudinal muscle of the anal canal.

In 1949 Courtney presented a somewhat detailed and controversial description in which he "indicates that the levator ani and deep external sphincter muscles should be considered, both anatomically and clinically, as one muscle." Although these muscles have an intimate anatomical relation this dissentient conception, although perhaps simplifying the terminology, would tend to add further confusion to an already controversial anatomical region.

In 1953 Uhlenhuth presented his *Atlas on Pelvic Anatomy,* in which he described the anorectal musculature in great detail. His excellent illustrations would seem to leave little doubt regarding the trilaminar arrangement of the external anal sphincter muscle (fig. 33).

Disregarding the variations in size and the disposition of the various individual muscle fibers, repeated dissections by the author have established the anatomy of this muscle as herein described, having a definite trilaminar arrangement quite apparent even in the newborn (fig. 34). In our opinion, this should be accepted as presenting the true and scientific basis for the pathogenesis and surgery of this region—the important and practical consideration.

As now generally accepted and described the external anal sphincter muscle is divided into Subcutaneous, Superficial and Deep portions.

The Subcutaneous External Sphincter

This portion of the external anal sphincter is situated immediately below the anal skin and is usually distinctly palpable, particularly lateral to the anal canal. It occupies the perianal space and may often be outlined by sight (fig. 35). It usually has an



FIG. 35. Subcutaneous external sphincter encircling anus. (Milligan and Morgan: *Lancet*, 1934.)

annular arrangement and is disposed somewhat external to, or on the same longitudinal plane with the internal anal sphincter muscle. It forms the lower wall of the anal canal and is the *only* muscle surrounding the anal orifice. During contraction it approximates the inner margin of the internal sphincter muscle.

Posteriorly the fibers are usually annular and bridge the interval between the converging legs of the superficialis sphincter muscle, forming the so-called "weak spot" of the anal canal. Occasionally the fibers decussate and present posterior extensions continuous with the adjacent superficialis muscle. At times the entire muscle forms these posterior extensions and there is no annular bridging or "bar" posteriorly. The fibers occasionally decussate anteriorly and become continuous with the superficialis muscle (fig. 36).

Anteriorly in the female the subcutaneous external sphincter usually forms a prominent annular muscle which lies directly below the perianal skin and bridges the interval between the diverging legs of the superficialis muscle. This portion of the sphincter is usually torn in labor and incised in the episiotomy.

The Superficialis External Sphincter

The superficialis portion of the external anal sphincter sometimes referred to as the coccygeal portion, is an elliptical band of fibers which embraces the anal canal in a spindle-like manner. It lies slightly above and lateral to the subcutaneous muscle.

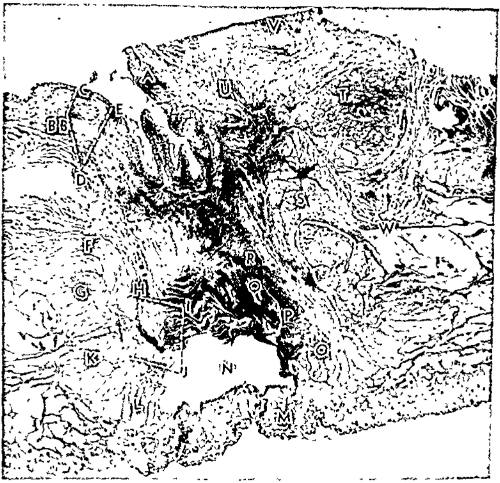


FIG. 34. Sagittal section of the anorectal region of a newborn male. Note that this section is cut somewhat off the median plane and passes through both the circular and longitudinal muscle coats of the bowel wall and includes a small portion of the cornified epithelium of the anal canal (see fig. 23). Also note that even in the newborn the three divisions of the external anal sphincter are quite distinct and that the fibro-elastic extensions from the longitudinal muscle, combined with the fascial reflections from the levator ani muscle (the conjoined longitudinal muscle), penetrate the subcutaneous portion of the external sphincter ani. Note also that the circular muscle of the bowel, the internal anal sphincter, can be followed to the intersphincteric line anteriorly where its sharp lower border is quite prominent. The relation of the levator ani muscle to the anterior rectal wall and to the prostate and the base of the bladder is particularly noteworthy in this section. Posteriorly the relations of the levator ani muscle to the deep portion of the external anal sphincter is well shown. CDE is a prominent gland of Lieberkühn with a solitary lymph follicle. This area has been enlarged to show the details of the submucosal and musculature structures on p. 153 (fig. 79). The section HIJ at the anorectal junction has been enlarged to show the large number of terminal nerve endings at this point (p. 295, fig. 153). The circumanal glands of Gay should be noted. A, rectal mucosa; BB, rectal musculature; F, levator ani muscle; G, profundus; K, superficialis; L, subcutaneous; M, anal skin; N, anal canal; O, fibro-elastic extensions (conjoined muscle); P, internal sphincter; Q, anal crypts; R, circular coat of rectum; S, levator ani muscle; T, prostate; U, Denonvilliers' fascia; V, bladder; W, deep transverse perineal muscle.

not the levator plate (see p. 83). Its fibers *surround the midportion* of the anal canal and in the male converge and insert into the central tendinus raphe, extending well anteriorly over the bulbocavernosus muscle as far as the rectractor scroti muscle (fig. 37). In the female, however, the homologous fibers diverge and, extending laterally, reach the pubic ramus and fuse insensibly into the fibers of the sphincter vaginae (bulbocavernosus muscle). A few of the fibers may insert into the central tendinous point of the perineum (fig. 38).

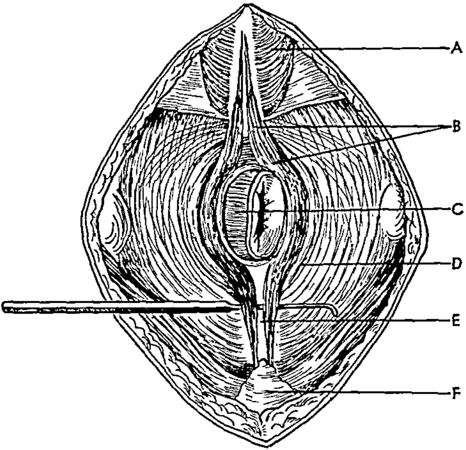


FIG 37. The superficial external sphincter ani. Drawn from dissection. Note the elliptical arrangement and the anterior extensions over the raphe. A, bulbocavernosus, B, superficial external sphincter; C, longitudinal muscle; D, profundus external sphincter; E, posterior communicating space; F, coccyx.

It is the largest, strongest and longest portion of the external anal sphincter. Partly aponeurotic and partly muscular, it arises from the postero-lateral aspect of the coccyx. It forms the important muscular component of the "ano-coccygeal ligament" (raphe),

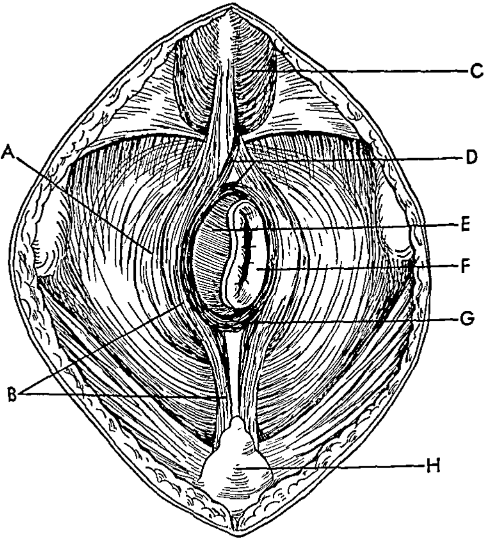


Fig. 36 Subcutaneous external sphincter. Drawn from dissection. Note that in this specimen the subcutaneous muscle has crossed anterior extensions and uncrossed posterior extensions. A, profundus external sphincter muscle; B, superficial external sphincter muscle; C, bulbocavernosus; D, subcutaneous external sphincter muscle; E, longitudinal muscle; F, anal skin; G, subcutaneous external sphincter muscle; *H, coccyx.*

denoting their similar embryologic origin (see Embryology, p. 53).

In the female the anatomic arrangement of the superficialis and subcutaneous muscles is of considerable importance in the repair of the anal sphincter and likewise in the surgery of fistula and fissure. In both sexes the anterior and posterior communicating spaces extend *directly* above the superficialis and below the deep sphincter ani muscles. In the female the anterior communicating space, however, is difficult to define.

The Deep External Sphincter Muscle

The deep portion of the external anal sphincter is for the most part an annular muscle usually without attachment to the coccyx. In its posterior half it is usually intimately attached along its upper border to the lower and posterior fibers of the puborectalis sling, (the posterior half of the ano-rectal muscle ring) (fig. 39). It is usually inseparable and indefinable by palpation from the latter muscle.

Anteriorly however it lies free and encircles the anterior half of the anal canal. Some of its fibers may decussate and extend laterally to become continuous with the transverse perineal muscles and insert into the ischium (fig. 40). In conjunction with the anterior fibers of the prerectal muscular extensions from the pubococcygeus muscle—the fibers of Luschka—it forms the anterior half of the anorectal muscle ring, which encircles the sphincteric portion of the rectum.

The Corrugator Cutis Ani Muscle

In the strict sense this is not a muscle. It occupies the perianal space and represents the tier-like terminal insertions of the fibroelastic extensions of the conjoined longitudinal muscle into the anoderm and perianal skin (fig. 41). These extensions originate at different levels from fibers which penetrate the substance of the subcutaneous external sphincter as well as from those which pass on either side of it. They represent anchoring points for the

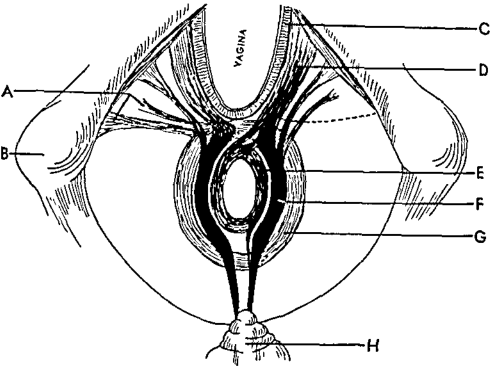


Fig. 38. External anal sphincter in the female (Schematic). Note that the *subcutaneous* portion of the external sphincter is usually annular but may partially decussate anteriorly or, less commonly, posteriorly. The *superficialis* arises, as in the male, from the sides of the coccyx, and surrounds the mid-portion of the anal canal in a spindle-shaped manner Many of its fibers become continuous with the bulbocavernosus of the same side and additional small bundles of uncrossed fibers extending to the pubic rami are commonly found. Some of its fibers insert into the perineal body. The *profundus* portion, in close relation to the puborectalis *posteriorly, surrounds the anal canal in an annular fashion. Its fibers may insert into* the central perineal tendon. In many cases, however, the bulk of its fibers cross and, becoming continuous with the superficial transverse perineal muscle, insert into the pubic ramus of the opposite side. The free borders of the levator ani muscles forming the genital hiatus are in close relation to these fibers of the profundus external sphincter. A, crossed fibers of profundus external sphincter ani; B, ischial tuberosity; C, vaginal wall; D, bulbocavernosus; E, subcutaneous external sphincter ani; F, superficialis external sphincter ani; G, profundus external *sphincter ani; H, coccyx.*

Anteriorly, crossed and more often uncrossed extensions of the superficialis muscle extend laterally in the fascial shelf and attach to the ischial tuberosity and the adjacent fascia. These fibers cross in close relation to the superficial transverse perineal muscles,

levator ani muscles which elevates the anal canal and corrugates the perianal skin. The muscle is of some importance in the surgery of hemorrhoids.

The Sphincter Ani Internus

The termination of the inner circular smooth muscle coat of the rectum projected into the anal canal is characterized by a gradual increase in its muscular component which forms the internal sphincter ani muscle. As already noted, this muscle is surrounded by the superficial and deep portions of the external anal sphincter and forms the upper two-thirds of the entire inner muscular layer of the anal canal. Approaching the skin it becomes somewhat fibro-elastic and presents a well-defined lower sharp margin which on a vertical plane lies somewhat internal to the inner border of the subcutaneous external sphincter (fig. 42).

Immediately below its lower margin the internal sphincter is separated from the upper border of the external subcutaneous sphincter by the insertions of the longitudinal muscle forming the anal intermuscular septum or depression or intersphincteric line which, as noted, is a definite and important landmark in the anal canal.

The internal anal sphincter forms the mesial muscular wall of the entire pecten or upper third of the anal canal which is lined

lature 4, 4, anal part of deep layer of pubo-anal muscle with fibrous plate attached to tip of coccyx 4 a, anal part of superficial layer of pubo anal muscle with fibrous plate attached to dorsum of coccyx. 5, aponeurosis between rectal capsule and ventrum of coccyx for attachment of retrorectal component of pubococcygeus. 8, puborectalis muscle, semitubular layer. 8 c, puborectalis muscle, cylindrical layer. 9, deep external sphincter ani. 10, superficial external sphincter ani (some of its bundles adherent to rectal wall). 12, 12, anorectal mucosa (cranial flap thrown upward). 12′, *anal mucosa (caudal flap); transition into skin.* 13, circular muscle of rectum. 14, internal sphincter in cranial flap of wall of anal canal. 15, longitudinal muscle of rectum in cranial flap of wall of anal canal. 15 a, inner longitudinal layer, cranial flap, thrown cranially. 15 a′, insertion into skin of inner longitudinal layer 15″, caudal flap of anal wall. 16, 16, ureteral catheter in postanal space and space between external sphincter and ischiorectal fat. 28, bulb of urethra. 30, right bulbocavernosus muscle. (From Uhlenhuth, E.: *Problems in the Anatomy of the Pelvis* Philadelphia: Lippincott, 1953.)

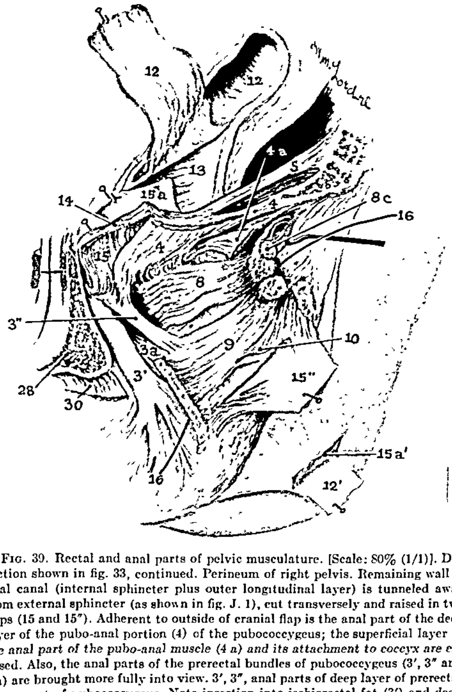


FIG. 39. Rectal and anal parts of pelvic musculature. [Scale: 80% (1/1)]. Dissection shown in fig. 33, continued. Perineum of right pelvis. Remaining wall of anal canal (internal sphincter plus outer longitudinal layer) is tunneled away from external sphincter (as shown in fig. J. 1), cut transversely and raised in two flaps (15 and 15"). Adherent to outside of cranial flap is the anal part of the deep layer of the pubo-anal portion (4) of the pubococcygeus; the superficial layer of *the anal part of the pubo-anal muscle (4 a) and its attachment to coccyx are exposed.* Also, the anal parts of the prerectal bundles of pubococcygeus (3', 3" and 3 a) are brought more fully into view. 3', 3", anal parts of deep layer of prerectal component of pubococcygeus Note insertion into ischiorectal fat (3') and deep external sphincter (3"). 3 a, anal part of the superficial layer of prerectal muscu-



FIG. 41. The corrugator cutis ani muscle (female).

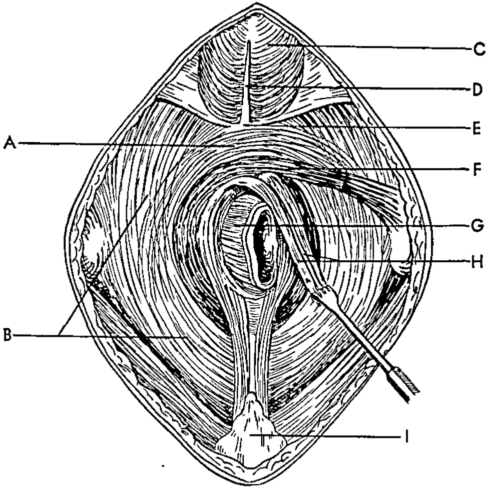


FIG. 40. The profundus external sphincter (male). Drawn from dissection. The superficialis muscle and the anterior raphe have been retracted posteriorly to show the annular encircling fibers of the profundus external sphincter ani. Incidentally, the anterior fibers of the levator ani encircling the rectum are well shown, just posterior to the central tendineus point of the perineum. A, anterior fibers of levator ani; B, levator ani muscle; C, bulbocavernosus; D, median raphe; E, central tendinous point of perineum; F, profundus external sphincter muscle; G, longitudinal muscle; H, superficialis muscle and anterior raphe retracted; I, coccyx.

by squamous epithelium (anoderm) and below which is the important areolar tissue containing the anal ducts, glands, connecting veins, muscularis mucosae, lymphatics and nerve endings.

The internal anal sphincter plays but a small though sometimes

important part in the continence of the anal canal because it lies in close relationship to the critical sensory zone initiating the defecatory reflexes, etc. This is significant to the pull-through operations. It is innervated primarily through the sympathetic and parasympathetic nerves, but because of its intimate embryologic and anatomic relation to the combined anorectal musculature its activities may follow direct mechanical or contigual stimuli, as well as those from direct or reflex, inherently, nerve stimuli. This has complicated the studies on the neurophysiology of the anal musculature and has confused separate or individual responses in this region. The internal anal sphincter is of the nonstriated variety.

Its dimensions vary roughly from 5 to 8 mm. in thickness and from 3 to 3.5. cm. in length. It is often of different thicknesses throughout its circumference, becoming somewhat more fibrous at the commissures. Its sharp lower margin encircled by the fibro-elastic fibers of the conjoined longitudinal muscle has a white glistening appearance not to be confused with fibrous tissue or a pectenosis or pecten band.

In the chronic posterior anal fissure fibrosis and excessive spasm may also involve the internal sphincter as well as the subcutaneous external sphincter. Partial division of the internal muscle following *complete* division of the external subcutaneous sphincter may therefore be necessary for permanent results.

Although quite variable, the average heights and widths of the several divisions of the external anal sphincter muscle are as follows:

	cm.	*cm.*
Subcutaneous external sphincter	0.3–0.7	0.3–1
Superficialis external sphincter	0.8–1.5	0.5–1.5
Deep external sphincter	0.4–1	0.5–1

The Longitudinal Muscle of the Anal Canal

In passing through the pelvic diaphragm the terminal rectum is enveloped by fibro-muscular extensions from the levator ani muscle—the puboanal muscle of Uhlenhuth and its fascia. These

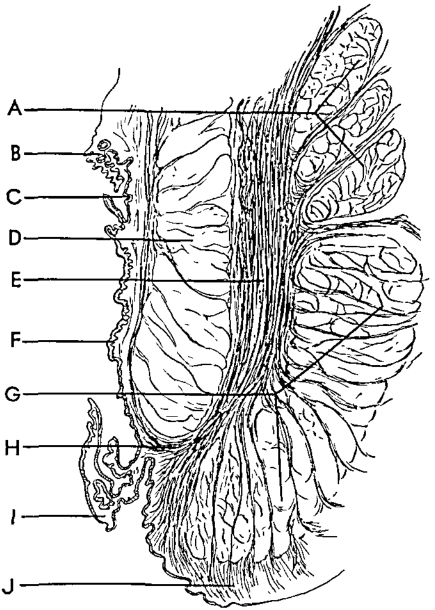


FIG. 42 Schematic longitudinal section of the anorectal junction. Compare with fig. 43. A, levator ani; B, rectal gland; C, anal crypt; D, circular muscle; E, longitudinal muscle; F, pecten; G, external sphincter; H, intermuscular septum; I, anal tag; J, corrugator cutis ani muscle.

extensions fuse with the longitudinal muscular coat of the rectum and anal canal to form a conjoined fibro-muscular sheath—the conjoined longitudinal muscle or tendon (Levy); the composite longitudinal muscle (C. Naunton Morgan); the combined longitudinal muscle (Courtney).

This conjoined muscular sheath containing both smooth and striated muscle fibers connects the puborectalis and pubococcygeus muscles to the rectal wall. It forms a part of the important anorectal muscle ring, and extends caudad between the *internal* anal sphincter and the *deep* and *superficial* portions of the *external* anal sphincter muscle and so becomes an integral component of the anorectal sphincter mechanism (figs. 42 and 43).

Upon reaching the interval between the lower margin of the internal sphincter muscle and the upper border of the subcutaneous external sphincter it takes a firm fanlike attachment to the skin of the anal canal—the anoderm—and forms the so-called important anal intermuscular septum (see anal intermuscular septum, p. 78).

From the intermuscular septum the main layer of the conjoined longitudinal muscle extends both upward and downward below the anoderm. The upward extensions envelop the lower border of the internal sphincter muscle and become firmly attached to the pecten of the anal canal. A few fibers continue above the anorectal line into the internal hemorrhoidal annulus. This fibromuscular attachment to the pecten forms the caudal and major portion of the "Musculus Submucosae Ani" according to Fine

stained histologic section (×200). Note the extensions from the elvator ani muscle into the longitudinal coat of the rectal wall to form the conjoined longitudinal muscle. Surrounding and supporting the anal canal, the conjoined longitudinal extensions form a complete fascial collar which is of considerable significance in the surgery and patholysis of anorectal disorders, particularly in the etiology of anal fissure and fistula. The three divisions of the external sphincter ani muscle are well shown. Note the different directions of their muscle fibers. The anorectal junction shows a slight overlapping of the true rectal mucosa into the crypt A, levator ani muscle; B, fusion of levator and longitudinal muscle of the bowel wall; C, rectal mucosa; D, anorectal (denate) line (crypt); E, internal anal sphincter; F, pecten; G, skin tab in lower portion of anal canal; X, Y, Z, three divisions of the external anal sphincter muscle.

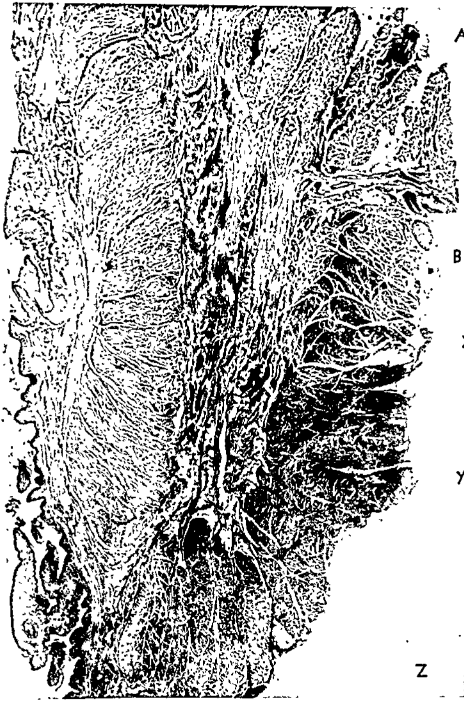


Fig. 43. Longitudinal view of the anorectal junction, reproduced from a

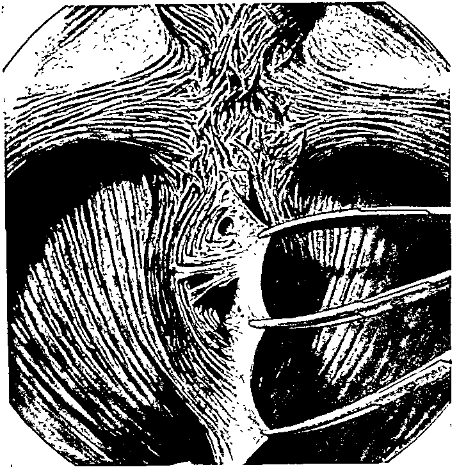


FIG. 44. The extensions of the conjoined longitudinal muscle passing through the individual muscle bundles of the subcutaneous external sphincter muscle (Courtney)

a distinct conjoined muscular septum only below the levator-rectal junction.

The conjoined longitudinal muscle is significant to the physiology, pathology and surgery of the anal canal. It forms the essential framework for the architecture and trilaminar arrangement of the external anal sphincter muscle and for its integration with the levator ani muscle. It is largely through the distribution of its fibro-muscular extensions that the levator ani muscle exercises its important levator and sphincteric action on the anal canal.

and Lawes. The cranial portion of this musculus is formed by extensions from the muscularis mucosae of the terminal rectum—the sustentator tunicae mucosae of Kohlrausch—which also attaches to the pecten of the anal canal.

The downward extensions of the main layer continue below the anoderm around the medial aspect of the subcutaneous external sphincter muscle, and fanning out into several layers they insert into the perianal skin to form the inner fibers of the corrugator cutis ani muscle.

In addition to the main layer just described the conjoined longitudinal muscle gives off fibromuscular extensions which pass through the substance of the subcutaneous external sphincter muscle as well as around its outer surface (fig. 44). The fibers which pass through the individual muscle bundles of the subcutaneous sphincter are thinner and more elastic (fig. 45). They terminate and insert into the perianal skin. Those fibers which pass around the outer surface of the subcutaneous muscle also insert into the perianal skin. These terminal extensions together with the medial extensions form the corrugator cutis ani muscle.

Milligan describes a lateral extension of the conjoined longitudinal muscle which passes outward between the subcutaneous and superficialis portions of the external anal sphincter and forms a transverse perianal fascial layer—"the transverse septum of the conjoined longitudinal muscle"—which divides the ischiorectal fossa into perianal and ischiorectal spaces (fig. 46). These spaces are of surgical significance in the pathogenesis and extensions of anorectal abscess and fistula.

There are no extensions of the conjoined longitudinal muscle which pass through the *internal sphincter muscle.*

A number of fibromuscular extensions from the longitudinal muscle coat of the rectum gain attachments to the coccyx, urethra, prostate, etc., e.g., the rectococcygeus muscle, the "upper" and lower recto-urethralis muscles. These muscles are sometimes considered as arising from the conjoined longitudinal muscle of the anal canal. It may be noted, however, that the latter becomes

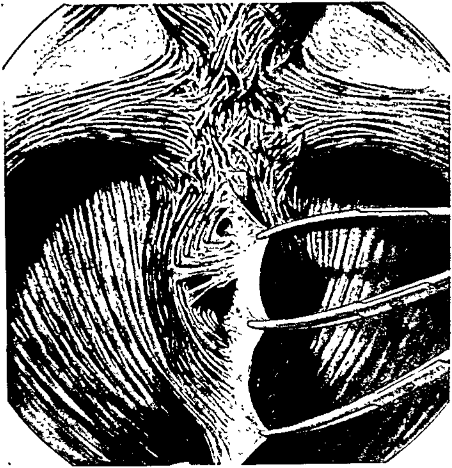


FIG. 44. The extensions of the conjoined longitudinal muscle passing through the individual muscle bundles of the subcutaneous external sphincter muscle (Courtney).

a distinct conjoined muscular septum only below the levator-rectal junction.

The conjoined longitudinal muscle is significant to the physiology, pathology and surgery of the anal canal. It forms the essential framework for the architecture and trilaminar arrangement of the external anal sphincter muscle and for its integration with the levator ani muscle. It is largely through the distribution of its fibro-muscular extensions that the levator ani muscle exercises its important levator and sphincteric action on the anal canal.



FIG. 45. Photomicrograph of a longitudinal section through the subcutaneous portion of the external anal sphincter, showing how this muscle is penetrated by the *septal extensions of the longitudinal muscle which insert into the perianal* skin Note the nerve fibers in these extensions and the hair follicles and fat of the skin A, fibro-elastic extensions of the longitudinal muscle; B, subcutaneous external sphincter ani; C, nerve fibers; D, hair follicles; E, fat.

The attachment of these extensions to the anoderm of the anal canal as the intermuscular septum and their insertion into the pecten supports the anal canal and prevents its eversion.

From the pathological standpoint, the fascial encuffment of the upper third of the anal canal by the conjoined longitudinal muscle and its extensions at the level of the intermuscular septum have a directive influence on the spread of anorectal infections as well

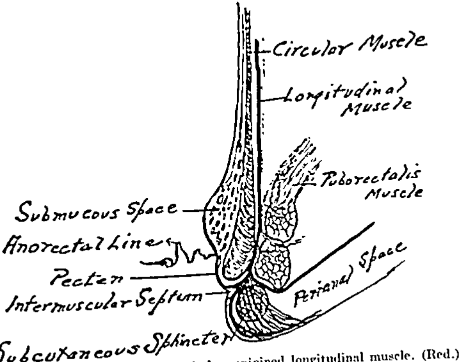


FIG. 46. The terminal extensions of the conjoined longitudinal muscle. (Red.)

as the location of the internal openings of fistulas and their main tracts relative to the anal musculature.

From the surgical standpoint, the importance of conserving the terminal extensions of the conjoined longitudinal muscle into the perianal skin and including them in the ligature of the hemorrhoidal stump has been stressed by Milligan and C. N. Morgan (and their co-workers), and more recently by Blaisdell as well as by the author. This simple technique prevents high retraction of the hemorrhoidal stump and unnecessary denudation of the anoderm and mucosa overlying the hemorrhoids.

The undesirable sequelae of the Whitehead operation for hemorrhoids and other amputative techniques result mainly from a more or less complete destruction of the attachments of the fibro-muscular extensions of the conjoined longitudinal muscle.

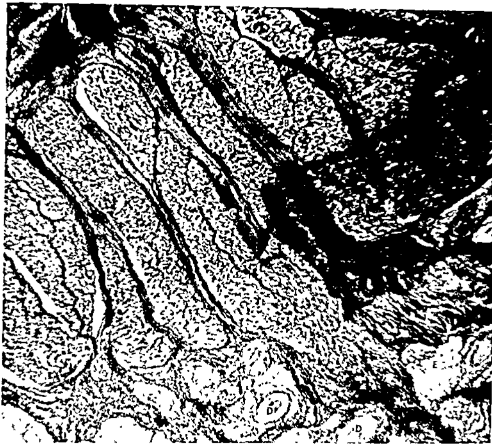


FIG. 45 Photomicrograph of a longitudinal section through the subcutaneous portion of the external anal sphincter, showing how this muscle is penetrated by the septal extensions of the longitudinal muscle which insert into the perianal skin Note the nerve fibers in these extensions and the hair follicles and fat of the skin. A, fibro-elastic extensions of the longitudinal muscle; B, subcutaneous external sphincter ani; C, nerve fibers; D, hair follicles; E, fat.

The attachment of these extensions to the anoderm of the anal canal as the intermuscular septum and their insertion into the pecten supports the anal canal and prevents its eversion.

From the pathological standpoint, the fascial encuffment of the upper third of the anal canal by the conjoined longitudinal muscle and its extensions at the level of the intermuscular septum have a directive influence on the spread of anorectal infections as well

agreement (fig. 47). This so-called septum is formed by the firm attachment of the conjoined longitudinal muscle into the skin of the anal canal—the anoderm—which results in a depression between the firm lower margin of the internal sphincter and the adjacent subcutaneous muscle. The septum is preferably referred to as the anal intermuscular groove, depression, line or interval. In general it corresponds to the "white line" of Hilton. It is an important readily palpable landmark of the anal canal.

"Musculus Submucosa Ani"

As previously noted, terminal fibro-elastic smooth muscle fibers of the conjoined longitudinal muscle encircle the lower margin of the internal sphincter muscle and are attached to the connective tissue of the pecten. Some of these fibers extend upward above the dentate line.

Smooth muscle fibers of the well developed muscularis mucosae of the terminal rectum—the sustentator tunicae mucosae of Kohlrausch—likewise take a firm attachment to the pecten and fuse with the cranial extensions of the conjoined muscle (fig. 48).

These combined smooth muscle fibers are referred to by Fine and Lawes as a "Musculus Submucosa Ani." This tiny aggregation of muscle fiber is variable. It is situated below the modified skin of the anal canal—the anoderm—rather than the "mucosa."

Fine and Lawes consider that a spasmodic contraction of this musculus has been confused with the pecten band originally described by Miles as a pathological entity. This confusion is no doubt possible and both spasm and fibrosis may co-exist in variable degree. However a "pecten band" or "umbrella ring" which persists under anesthesia is probably a fibrous infiltration in the anal canal rather than a spasmodic contraction of the "Musculus Submucosae Ani" muscle.

The difficulty in grossly differentiating smooth muscle fibers from fibrous tissues which have a very similar appearance has also led to some confusion in the controversial subject of pecten band, "pectenosis," pectenitis, etc.

THE ANAL INTERMUSCULAR SEPTUM (GROOVE, DEPRESSION, INTERSPHINCTERIC LINE, ETC.)

As previously noted the insertions of the conjoined longitudinal muscle of the anal canal between the internal and the subcutaneous external sphincter muscles are generally considered as forming a more or less definite septum. This terminology of septum however is somewhat of a misnomer.

Wilde has demonstrated that these insertions are not sharply defined and do not form a definite septum. Our studies are in

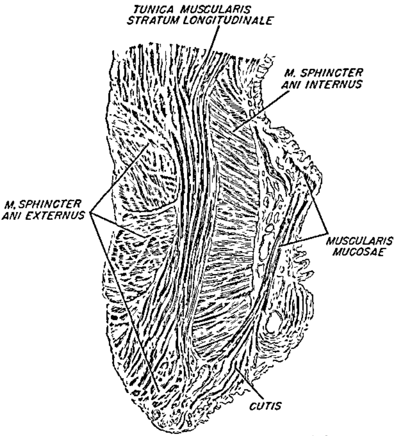


FIG. 47. Perpendicular section through the lower part of the rectum, showing the relations of the longitudinal layer of muscular fibers to the sphincter. Redrawn from Zuckerkandl, Emil: *Atlas der Topographischen Anatomie des Menschen*. Wein: 1900–04.

deep portion of the external anal sphincter and the fibro-elastic extensions from the levator fascia and the levator ani muscle to the longitudinal musculature of the rectum. In its posterior half the ano-rectal muscle ring is prominent, much stronger than anteriorly and considerably more mobile (fig. 49).

Anteriorly the ano-rectal muscle ring is formed by a thin layer of muscular extensions from the puborectalis muscle and a somewhat stouter band from the pubococcygeus muscle (prerectal bundle of Uhlenhuth; levator fibers of Luschka). These fibers fuse with the deep portion of the external anal sphincter muscle to complete the anorectal muscle ring in its anterior half. The anorectal ring as well as the entire anal sphincter musculature is narrower, thinner, shorter and weaker anteriorly, from the fascial as well as the muscular standpoint. In the female such an arrange-

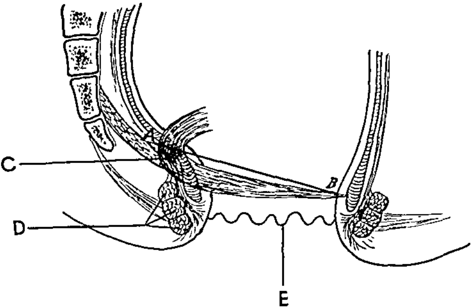


FIG. 49 The anorectal muscle ring (A to B). Note the decreasing level as well as the gradual divergence of the puborectalis muscular fibers away from the upper limits of the anal canal. C, puborectalis; D, three divisions of the external sphincter ani; E, anorectal line. Note also that the action of the puborectalis is rather sphincteric, while that of the pubococcygeus is levator.



FIG. 48. Longitudinal section of the anal canal showing: A, the subcutaneous external anal sphincter muscle; B, the internal anal sphincter muscle; C, the "musculus submucosa ani" extending from the intermuscular septum to the anorectal line.

The Ano-Rectal Muscle Ring

This important musculo-fascial ring or collar completely surrounds the ano-rectal junction. Its important components are the pubo-rectalis muscle (puborectalis sling) combined with the

tensions into the longitudinal musculature of the rectum, the puborectalis sling muscle becomes *the* most important component of the entire ano-rectal sphincter mechanism. It is therefore the key muscle to the preservation of anal continence.

Clinical experience, especially in fistula surgery, has emphasized the observation that the greater portion of the anal musculature may be severed without materially interfering with anal continence. However, when the ano-rectal ring is divided, particularly laterally, permitting relatively greater retraction of the entire musculature, some degree of incontinence is apt to follow.

Clinically the ano-rectal ring marks the upper limits of the internal hemorrhoidal plexus and it is therefore a landmark in the so-called high injection treatment for internal hemorrhoids.

Its contraction approximates the rectum and pubes, increases the acuteness of the ano-rectal angle and shortens and narrows the pelvic aperture.

Anococcygeal Ligament (Anococcygeal Body, Anorectal Shelf, Levator Shelf, Anococcygeal Raphe, Coccygeal Muscular Raphe, Etc.)

There is considerable looseness in the use of these terms.

The individual muscular components of the levator-ani muscle and the external anal sphincter gain attachment to the coccyx and sacrum by fascio-muscular and musculo-aponeurotic extensions or plates. These posterior plates consist of two distinct separate layers which may be conveniently referred to as levator and anal strata. Between these strata are two clinically important spaces: superficial and deep post anal spaces (fig. 51). The levator stratum or plate is a laminated musculo-aponeurotic shelf which consists of the following layers: 1) The posterior insertions of the pubococcygeus muscle (its puboanal and retrorectal components —Uhlenhuth) which are inserted into the ventrum of the coccyx by a very strong aponeurotic band or plate, which continues over the lower sacrum and diverges into the prominent anterior sacral

ment is obviously necessary to parturition. Posteriorly it is a readily palpable landmark in both sexes. Anteriorly it is palpable in the female only by *recto-vaginal bidigital examination* (fig. 50).

It may be emphasized that through its intimate attachment to the deep sphincter and through its conjoined fibro-muscular ex-

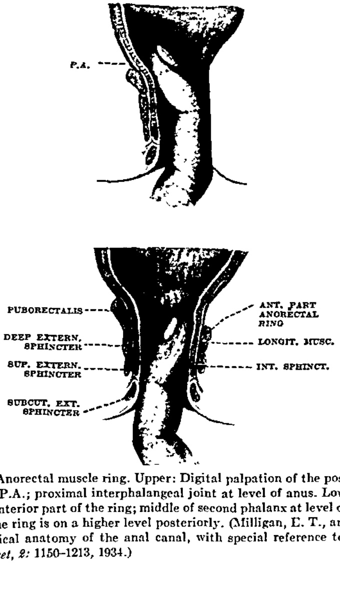


FIG. 50. Anorectal muscle ring. Upper: Digital palpation of the posterior part of the ring, P.A.; proximal interphalangeal joint at level of anus. Lower: Palpation of the anterior part of the ring; middle of second phalanx at level of the anus. Note that the ring is on a higher level posteriorly. (Milligan, E. T., and Morgan, C. N.: Surgical anatomy of the anal canal, with special reference to anorectal fistula. *Lancet, 2:* 1150–1213, 1934.)

tensions into the longitudinal musculature of the rectum, the puborectalis sling muscle becomes *the* most important component of the entire ano-rectal sphincter mechanism. It is therefore the key muscle to the preservation of anal continence.

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ligaments. 2) This cranial layer directly overlaps the next strata which consists of the musculo-fibrous insertions of the iliococcygeus muscle, which are directed downward and inwards to their coccygeal attachment. 3) The caudal stratum consists of a thin fibrous plate extending from the upper margin of the puborectalis sling muscle to the coccyx.

The superior surface of the levator plate is covered by supra-anal fascia or upper layer of the pelvic diaphragmatic fascia; its inferior surface is covered by the infra-anal fascia—lower layer of the pelvic diaphragmatic fascia (fig. 52).

The anal stratum from above downwards, consists of the following layers: 1) A thin fibrous extension from the deep external anal

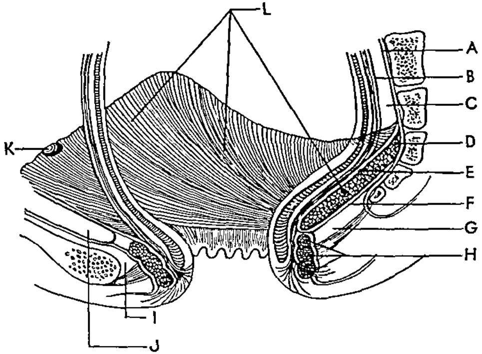


FIG. 51. The levator plate, "levator coccygeal raphe." A, parietal pelvic fascia; B, fascia of rectum; C, retrorectal space; D, coccygeal insertion of the levator plate—levator coccygeal raphe; E, supraanal—levator fascia; F, infraanal fascia; G, posterior communicating space; H, external anal sphincter; I, anterior communicating space; J, urogenital diaphragm; K, obturator foramen; L, levator plate—levator ani muscle.

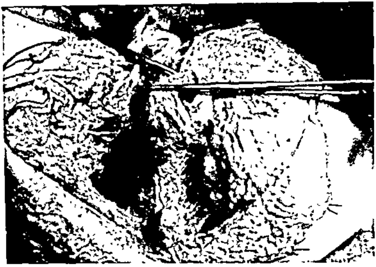


FIG. 52. The levator plate. The anococcygeal ligament in grasp of clamp has been retracted anteriorly to expose the inferior aspect of the levator plate, covered by infra-anal fascia.

sphincter muscle. This is, however, inconstant. 2) The posterior extensions, sometimes considered the origin, of the superficialis portion of the external anal sphincter muscle. This forms its main muscular and fascial component. 3) The areolar layer of the superficial posterior triangular space. 4) The superficial perineal fascia and skin. Occasionally small posterior extensions from the subcutaneous external sphincter muscle may also be found in this anal stratum.

Directly above the anal stratum and below the levator stratum is a potential space filled in with loose areolar tissue (the deep postanal space; posterior communicating space; subsphincteric space (Courtney).

The preferable terminology for these separate strata, at least from the clinical standpoint, would refer to the anal stratum as the anococcygeal ligament and the levator stratum as the levator plate or the levator coccygeal raphe.

The posterior communicating space between the two strata lined by the infra-anal fascia is the usual pathway of extension in the posterior "horseshoe" variety of anorectal fistula. Communica-

tion between the ischiorectal spaces is possible at other levels but these are uncommon.

These combined strata, musculo-ligamentous in character, support the rectal ampulla, the vagina and uterus. They also support the posterior half of the anal canal and its lining which is erroneously considered its weakest part, predisposing it to the common anal fissure.

The Coccygeal Body

The term coccygeal body (or gland of Luschka) is sometimes erroneously used in referring to the anococcygeal body or ligament. The coccygeal gland or body is a small mass about 3 mm. in all diameters, situated just below the tip of the coccyx. It is probably a vestigeal arterial structure related to the terminal ramifications of the median sacral vessels and the chromaffin nerves and the tail gut. The gland is of little surgical or anatomic importance. It bears no relation to the anus or anal canal and should not be referred to or confused with the important anococcygeal ligament. In rare instances it may be of some etiologic significance in congenital tumors of this region.

The Central Perineal Tendon (Tendinous Point) and Perineal Body

The central tendinous "point" of the perineum corresponds embryologically to the site of fusion of the anal tubercles and the pelvic bar (uorgenital septum) separating the sphincter cloaca into anal and genital portions. It forms, therefore, the point of junction and interlacing of several planes of fascia and muscles, and thus is the fixed point or fulcrum around which the anorectal and genito-urinary musculature, by either insertion or origin, coordinate their functional activities, particularly in the male.

Although referred to as a point, the fascial raphe actually extends from the inferior recess of the rectovaginal or prerectal spaces to the skin externally (fig. 53). From above downward, the following muscles or planes of fascia are intimately related to

it: the recto-urethralis in the male and the recto-vaginalis in the female; the converging layers of the supra-anal or superior pelvirectal fascia from the anterior margins of the levator ani muscles, the urethral fibers of the levator ani in the male and the vaginal fibers in the female; the thin areolar infra-anal fascia; the two layers of the triangular ligament, not so distinct in the female at this point; the fascial extensions from the bulbocavernosus and transverse perineal muscles; reflections of the deep perineal fascia (Buck); the strong reflections from Colles's fascia; the extensions from the external anal sphincter and from the conjoined longitudinal muscle and, finally, the fasciae of the skin (fig. 54).

In the male the central tendinous raphe is usually better developed than in the female, being situated between the anal canal and the bulb where it is more permanently fixed.

Lacerations through its fascial planes in the female may result in decreased contractility of the anal musculature and, by separation of the levator muscles and rupture or attenuation of the fascial reflections bridging the genital hiatus, predispose to rectocele, cystocele and prolapse.

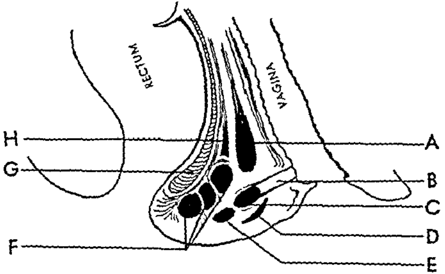


FIG. 53. The perineal body (schematic). A, levator ani; B, layers of triangular ligament; C, deep transverse perineal muscle; D, bulbocavernosus; E, superficial transverse perineal muscle; F, three divisions of the external sphincter; G, internal sphincter ani; H, rectovaginalis muscle.

tion between the ischiorectal spaces is possible at other levels but these are uncommon.

These combined strata, musculo-ligamentous in character, support the rectal ampulla, the vagina and uterus. They also support the posterior half of the anal canal and its lining which is erroneously considered its weakest part, predisposing it to the common anal fissure.

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In general, the inferior hemorrhoidal artery arising from the pudendal artery enclosed in the fascia lunata (Alcock's canal) supplies the posterior and lateral aspects of the anal musculature and adjacent integument by superficial and deep branches, while a separate transverse perineal branch, usually arising independently from the pudendal artery, supplies the anterior aspect of the anal musculature.

The inferior hemorrhoidal artery, arising from the pudendal artery, crosses the posterolateral aspect of the ischiorectal fossa sheathed in a reflection of fascia which also includes the venae comites, a few lymphatics and sometimes the nerves—the neurovascular hemorrhoidal stalk. There may be one or more branches direct from the pudendal artery in addition to the main branch described as the inferior hemorrhoidal (fig. 55).

The inferior hemorrhoidal artery commonly divides into three main branches. The first passes posteriorly and upward to supply the obturator internus, gluteus maximus and levator ani muscles. The second passes to the posterior aspect of the anal musculature and divides into smaller branches which supply the anococcygeal ligament and the posterior aspect of the anal musculature just lateral to the posterior commissure (the so-called fistula artery). The third and largest branch passes to the mediolateral aspect of the anal spincters, supplying them at different levels by smaller branches which finally reach the subepithelial tissues of the anal canal by penetrating or encircling the anal musculature and anastamosing with the terminal branches of the superior and middle hemorrhoidal vessels (fig. 56).

The anterior transverse perineal branch is usually a separate vessel arising from the pudendal artery and it might be conveniently termed the anterior sphincterian artery or branch, since it follows the nerve so named by Tuttle. This vessel branches from the pudendal artery just before the latter gives off the perineal artery which reaches the superficial perineal compartment. The main trunk of the pudendal artery continues between the layers of the urogenital diaphragm (the deep perineal compartment) and

Considered superficially the central tendinous raphe has no surgical significance. Its progressive recognition is most important in reaching the separable space between the prostate and the rectum. In fistula or prostatic surgery its destruction may result in considerable anorectal deformity.

The Arterial Supply to the Anal Musculature

The arterial supply to the anal canal and anal musculature is somewhat distinct from that of the rectum (q. v.) and to avoid confusion will be discussed at this point.

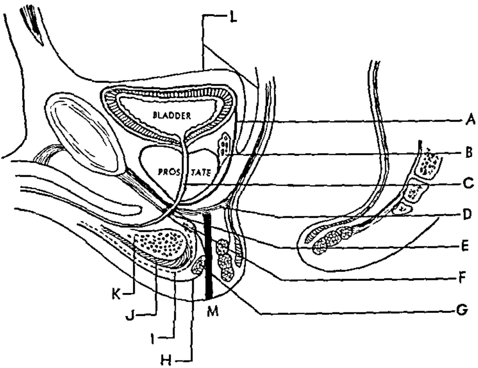


Fig. 54. The central tendon (schematic). Note that the central tendon extends from the skin to the recto-urethralis or recotvaginalis muscles. Its broad conception is of surgical significance in the approach to the prostate and rectovaginal spaces. A, Denonvilliers' fascia; B, seminal vesicles; C, prostatic urethra; D, rectourethralis; E, sphincter membr. urethrae, F, deep transverse perineal muscle; G, superficial transverse perineal muscle; H, Colles' fascia; I, perineal fascia (Buck's); J, bulbocavernosus; K, bulb; L, peritoneum; M, central tendinous point of perineum.



FIG. 56. The vascular pedicle of the inferior hemorrhoidal artery. The anal sphincter muscle has been elevated somewhat to demonstrate the different levels at which the arterial branches supply the muscle; this applies likewise to the nerves and is of surgical importance. The arterial branch, reaching the anal musculature near the posterior commissure, is the "artery of fistula." Note the anterior communicating space which is well shown below the anterior extensions of the superficialis portion of the external sphincter. Compare with fig. 55. A, inferior hemorrhoidal branches; B, "artery of fistula"; C, gluteus muscle; D, anterior raphe; E, anterior communicating space; F, anal margin; G, posterior raphe; H, sacrotuberous ligament.

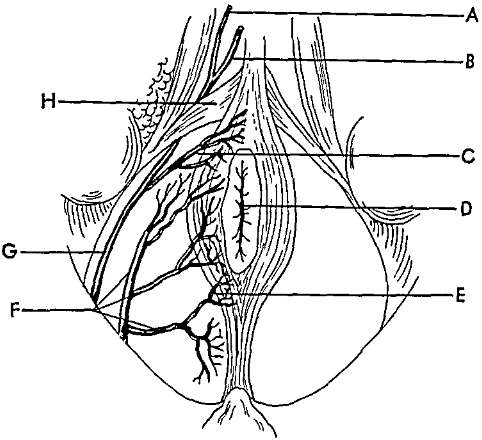


FIG. 55. The inferior hemorrhoidal artery. Drawn from dissection. The main branching of the inferior hemorrhoidal artery is inconstant. The distribution shown here is common. Note that the vessels, as do the nerves, cross the ischiorectal fossa from the posterolateral angle and not directly lateral, as is commonly shown. This point is of importance in local infiltration anesthesia and in the injection of the oil-soluble anesthetic, Anucaine. Note that the terminal branches enter the musculature at different levels. They ultimately anastomose with the terminal radicles of the superior hemorrhoidals through the pecten. Note also the anterior sphincterian branch which is fairly constant and is usually confused with the superficial transverse perineal branch, not shown here. A, pudendal artery; B, perineal artery; C, anterior sphincterian artery; D, anus; E, "artery of fistula"; F, inferior hemorrhoidal artery; G, pudendal artery; H, superficial transverse perineal muscle.

finally divides into its terminal branches, the deep and dorsal arteries of the penis (clitoris). The perineal artery gives off a branch in the superficial perineal pouch which should not be confused with the anterior transverse perineal branch (sphincterial



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branch) mentioned above. The latter vessel has caused some confusion because it extends mesially toward the anal canal behind the posterior margin of the urogenital diaphragm but is definitely separated from it by a reflection of Colles's fascia. This vessel reaches the anterior aspect of the anal canal, supplies the musculature in this situation and anastomoses freely with the anterior terminals from the lateral branches of the inferior hemorrhoidal artery; after giving off several smaller branches it finally ramifies in the perineal body and overlying skin.

In the genital triangles the perineal artery gives off several small transverse branches to supply the bulb, bulbocavernosus and ischiocavernosus muscles and, continuing in the interval between these muscles, finally terminates into the scrotal or labial branches.

The pudendal artery by its deep transverse branches supplies the bulbo-urethral glands (Cowper's glands, Bartholin's gland) and the urethra membranacea muscle. The midsacral artery, coursing down the anterior aspect of the sacrum on the parietal fascia, reaches the anococcygeal body and supplies it and the coccyx, finally ramifying in the skin over the coccyx and anococcygeal ligament.

The terminal anastomosis of the arteries in the pecten of the anal canal has been emphasized as important in the etiology of the common anal fistula, the vascular sheaths supposedly directing the infection to the adjacent perianal or ischiorectal spaces or perirectal tissues. The branches reaching the posterior aspect of the anal ring at 5 and 7 on the clock, respectively, have been referred to as the "fistula" branches.

Venous Supply

Although the veins follow essentially the same course and give off branches corresponding fairly closely to the arteries, they require additional description because of their relation to the forma-

tion of hemorrhoids and perianal hematomata (external thrombotic hemorrhoids) (see Veins of the Rectum, p. 94).

At the anal verge the inferior hemorrhoidal veins are prominent and form an indefinite plexiform arrangement which is commonly referred to as the external hemorrhoidal plexus. Terminal radicles from this plexus anastomose in the pecten of the anal canal with the terminal radicles from the ampullary enlargement of the internal arteries and veins which form the more important internal or superior hemorrhoidal venous plexus (fig. 57).

Current proctologic descriptions sometimes imply that there is a sharp line of demarcation between the external hemorrhoidal plexus and the internal. This is a variable factor and somewhat dependent on age and associated pathologic processes. Careful dissections show fairly constant overlapping between the two plexuses, both of which are related afferently to the portal as well as to the caval systems (fig. 58).

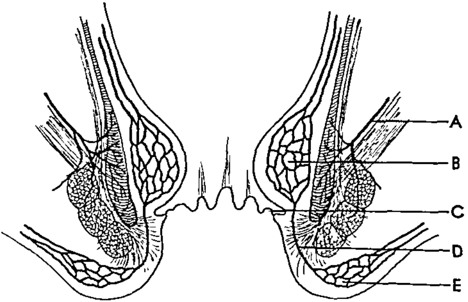


FIG 57. The anorectal veins (schematic). A, middle hemorrhoidal veins; B, superior hemorrhoidal plexus, C, anorectal line; D, connecting capillary between the two plexuses; E, external hemorrhoidal plexus.

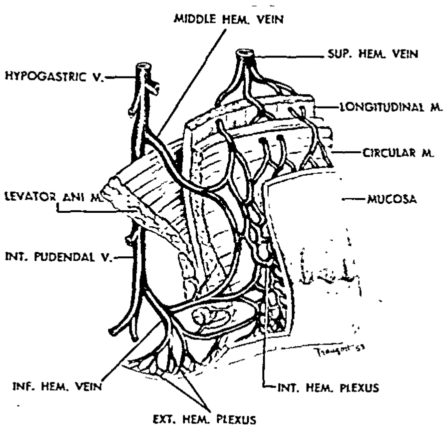


FIG. 58 Venous drainage of the rectum and anus showing the superior or internal and the inferior or external hemorrhoidal plexuses. (After Granet.)

The external hemorrhoidal veins also drain into the internal plexus. This is well exemplified in hemorrhoidal surgery when traction on the internal hemorrhoidal plexus causes a prompt distension of both plexuses.

The original investigations of Reuther on the anastomotic arrangement of the hemorrhoidal and portal venous systems are instructive and show that the degree of anastomosis between these veins increases with age and the degree of hemorrhoidal disease. Reuther further invites attention to the extent of rectal submucosal anastomoses and varix formation between the middle and superior hemorrhoidal veins which is sometimes quite prominent in portal

obstruction and readily demonstrable by proctoscopic observation.

Palpable Landmarks of the Anal Musculature

Careful palpation and identification of the normal anal landmarks are prerequisite to an appreciation of the abnormal. Both the normal and abnormal variations may have an important bearing on the contemplated surgery.

The diameter and length of the anal canal and the tone, contractility and mobility of its musculature are essential preoperative determinants in fissure and fistula surgery.

The following landmarks are palpable and important:

1. The subcutaneous external sphincter, usually entirely annular, sometimes divergent posteriorly
2. The lower border of the internal sphincter ani
3. The intermuscular septum, separating 1 and 2 above
4. The *anorectal muscle ring* formed posteriorly by the strong encircling puborectalis muscle and the deep anal sphincter; anteriorly by the thin band of levator ani fibers (Luschka) and the deep anal sphincter
5. The levator ani muscles and the levator plate.

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Review

Serial Dissection of the Perineal and Anorectal Musculature in the Male

Plates I–VIII are careful serial dissections of the same specimen and should be studied in sequence.

PLATE I

First Stage of Dissection

Colles' fascia (deep layer of the superficial fascia) has been removed. On the left side, the fibrofatty tissues of the ischiorectal fossa have been dissected out, exposing the levator and the external anal sphincter muscles. On the right, the fat pad of the ischiorectal fossa overlies the gluteus maximus. Note the intimate connection of the fibrous trabeculae to the anal fascia (infra-levator or infra-anal fascia).

The *subcutaneous external sphincter* encircling the anal canal posteriorly is particularly well shown. These are the muscular fibers which must be *entirely* divided as a minimum procedure in the surgical treatment of anal fissure.

The probe traverses the posterior communicating space from one ischiorectal fossa to the other. The Allis clamp overlies the anterior extensions of the subcutaneous and superficialis portions of the external anal sphincter, and marks the central tendinous point of the perineum.

Key: (A) Anterior extensions of the superficial external sphincter; (B) central tendinous point of perineum; (C) fibroelastic extensions of the longitudinal muscle; (D) anal skin margin; (E) subcutaneous external sphincter ani; (F) superficial external sphincter ani; (G) fat of ischiorectal fossa; (H) posterior communicating space traversed by probe.



Review

Serial Dissection of the Perineal and Anorectal Musculature in the Male

Plates I–VIII are careful serial dissections of the same specimen and should be studied in sequence.

PLATE I

FIRST STAGE OF DISSECTION

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PLATE II

Dissection Has Been Continued

Note the anterior extensions of the superficial external sphincter ani; the superficial transverse perineal muscles. Darning needles transfix the fibro-elastic extensions of the longitudinal muscle just above the anal skin margin, to show their tensile strength. The fat of the right ischiorectal fossa has been cleaned out, exposing the inferior hemorrhoidal artery arising from the canal in the obturator fascia (Alcock's canal).

Key: (A) Superficial external sphincter ani muscle; (B) superficial transverse perineal muscle; (C) anal skin; (D) fibro-elastic extensions of the longitudinal muscle transfixed with darning needles; (E) inferior hemorrhoidal pedicle; (F) coccyx; (G) levator ani muscle.



PLATE III

The Anterior Raphe of the Superficial and Subcutaneous External Anal Sphincter Has Been Dissected from the Median Septum of the Bulbocavernosus and is Retracted Posteriorly over the Anal Skin by the Allis Clamp

This exposes the anterior communicating space. Note the well-developed bulbocavernosus. The Hagedorn needle embraces the three divisions of the external anal sphincter. The darning needle lies just below an arterial branch from the pudendal artery which marks the deep level of the profundus portion of the anal sphincter muscle, in contrast to the lower level of the levator ani. Note also the crossed muscular branch from the profundus supported on two match sticks.

Key: (A) Perineal artery; (B) levator ani; (C) bulbocavernosus; (D) crossed extension from the profundus external sphincter ani; (E) central tendinous point; (F) Hagedorn needle embraces the entire external sphincter ani muscle; (G) anal skin; (H) longitudinal muscle; (I) anterior raphe retracted; (J) coccyx.



PLATE IV

Dissection Continued to Expose the Superficial Perineal Muscles

These muscles are exceptionally well developed. The inferior layer of the triangular ligament is also partly exposed. Note the anterior fibers of the levator ani muscle (the fibers of Luschka) which completely surround the anterior aspect of the rectum. The large match overlies the recto-urethralis muscle which is a fibromuscular fascial layer rather than a distinct muscle and its identification as a distinct structure in perineal surgery is important. The handle of the probe passes between the levator ani and the rectal wall and occupies the supralevator space at its lowermost level. The longitudinal muscular coat of the rectum, overlaid by supra-anal fascia, comes partially into view above the dark anal skin. The small match lies below the perineal artery which has been shifted somewhat laterally from its usual course between the ischiocavernosus and bulbocavernosus muscles.

Key: (A) Ischiocavernosus; (B) bulbocavernosus; (C) anterior raphe; (D) superficial perineal pouch; (E) triangular ligament; (F) superficial transverse perineal muscle; (G) anterior fibers of levator ani muscle; (H) probe handle in supralevator space; (I) longitudinal muscle; (J) anal skin; (K) coccyx; (X) perineal artery.



PLATE V
Dissection Continued

The bulbocavernosus muscle has been partially dissected from the lower layer of the triangular ligament, the urethra having been cut across. Note the extent and form of the triangular ligament. Behind the ligament is the prostate. The match lies in the interval between the prostatic and pubococcygeus fibers of the levator ani. This dissection illustrates the possibilities for the extension of infections from the genito-urinary organs to the perirectal spaces.

Key: (A) Bulbocavernosus, dissected from triangular ligament; (B) ischiocavernosus; (C) urethra; (D) triangular ligament (urogenital diaphragm); (E) prostate; (F) ischiorectal fossa; (G) anal skin; (H) coccyx; (I) gluteus maximus; (J) levator ani muscle.



PLATE VI

The Rectum Has Been Retracted Somewhat Anteriorly to Expose Its Postero-inferior Aspect

The anococcygeal tissues have been retracted anteriorly over the anal skin by the Allis clamp. Note the encircling fibers of the puborectalis muscle in contrast to the pubococcygei and iliococcygei which continue posteriorly to form the levator plate and insert partially into the supra-anal fascia, the cut edge of which is shown. Behind the exposed rectum lies the coccygeal stump.

Key: (A) Longitudinal muscle; (B) ischial tuberosity; (C) sacrotuberous ligament; (D) anal skin; (E) anococcygeal ligament retracted anteriorly; (F) external anal sphincter; (G) puborectalis muscle; (H) pubococcygeus muscle; (I) iliococcygeus muscle; (J) fascial edge; (K) rectal wall exposed; (L) coccyx excised.



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A
B
B
C
D
E

PLATE VII

THE LEVATOR ANI FROM ITS LOWER SACRAL INSERTION TO ITS PUBORECTALIS FIBERS HAS BEEN SEPARATED FROM THE RECTUM

The needle shows its thickness. Note its more intimate fascial relation where the prominent encircling fibers of the puborectalis form the anorectal muscle ring The posterior median raphe, including the superficial external sphincter muscle has been retracted anteriorly

KEY. (A) Posterior raphe, retracted anteriorly; (B) levator ani; (C) rectum; (D) gluteus maximus; (E) stump of coccyx


A
B
C
D
E
F
G
H

PLATE VIII

The Levator Ani Muscles Have Been Divided in the Anteroposterior Plane and Suspended on a String

In this subject the muscles are particularly well developed A fenestrated sound lies in the membranous urethra behind which is the prostate covered with the glistening fascia of Denonvilliers (the peritineoprostatic fascia). Compare the supralevator and ischiorectal spaces in this illustration and note that the supralevator space is much more extensive in its relation to the prostate, base of the bladder, and anterolateral aspects of the rectum.

Key: (A) Sound in membranous urethra; (B) prostate; (C) supralevator space; (D) cut edge of levator ani; (E) ischiorectal space; (F) anus; (G) rectal wall; (H) coccyx.



A
B
C
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E
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veloped the puborectalis muscle is usually readily distinguishable anatomically and clinically from the pubococcygeus, at least in its posterior half, where it forms the major portion of the anorectal muscle ring—the most important component of the anorectal sphincter mechanism (p. 80).

Phylogenetically the levator ani muscles are considered as representing converted tail musculature and the puborectalis muscle, as noted by C. Naunton Morgan, is considered as a special adaptation of the pubococcygeus to form a stronger muscle with sphincteric functions in orthograde mammals.

"In pronograde mammals such as the dog, the pelvic aperture is a mesial slit which occupies the whole length of the pelvic outlet, from the symphysis pubis to the tail. The aperture is guarded by the pubo-coccygeus muscles which lie on either side of it and which compress the visceral canals from the sides (fig. 59). In orthograde mammals, the posterior part of the pelvic outlet is

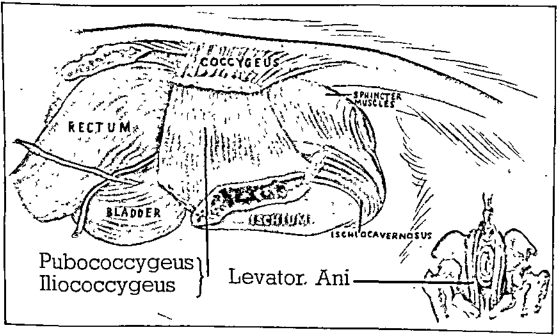


FIG. 59. Left lateral view of the pelvic floor of a dog.

CHAPTER IV

The Levator Ani, Coccygeus, Rectococcygeus and Recto-urethralis Muscles

The Levator Ani Muscle

This extensive pelvic muscle is of particular proctologic interest because of its intimate anatomic relation to the pelvic viscera and its integration into the fascial capsules and muscular walls of the perineal outlets, particularly the anal canal. Moreover the complex parietal and visceral fascial planes in the pelvis as well as the perineopelvic spaces have been largely established on the basis and terminology of the levator ani muscles. Their proper anatomic conception is therefore most essential for an understanding of perineopelvic pathology and surgery.

Considerable confusion still prevails concerning the correct anatomical disposition as well as the terminology of the several portions of the levator ani muscles. Their precise function in pelvic visceral support, particularly in the female is yet to be fully evaluated.

The puborectalis muscle has usually been included in the descriptions of the pubococcygeus muscle and not usually considered a separate muscle. This has resulted in some confusion regarding its anatomical descriptions and has minimized its surgical importance, particularly in proctology. Even though poorly de-



Fig. 60. Deep layer of diaphragmatic parts of levator ani. [Scale: 84% (1/1)]. Right half of pelvis. Inferior and presacral hypogastric wings freed of their attachments and removed. Bladder, prostate and stump of rectum pulled out of pelvic cavity and turned down. Parietal endopelvic fascia raised as far dorsal as cranial margin of coccygeus, and musculature of pelvic floor (diaphragma pelvis) exposed. Only the cranial (deep) layer of diaphragmatic parts of levator ani are visible. 1, 1', puboprostatic bundles of pubococcygeus. 2, pubobulbar component of pubococcygeus, diaphragmatic part. 3, prerectal component of pubococcygeus, deep layer of diaphragmatic parts and insertions into capsule of prostate. 4, puboanal component of pubococcygeus, deep layer of diaphragmatic part, and its insertion into rectal capsule by means of fibrous cords. 5, 5', 5", retrorectal component of pubococcygeus and its insertion into dorsum of rectum and ventrum of coccyx by means of aponeurotic plate 5' and 5". 6, iliococcygeus, deep layer. 7, coccygeus. 8, puborectalis muscle. 15, wall of rectum (outer longitudinal muscle layer). 39, fascial capsule of rectum. C 1-4, Coccygeal vertebrae. (From Uhlenhuth, E.: *Problems in the Anatomy of the Pelvis*. Philadelphia: Lippincott, 1953.)

closed and supported by the pelvic floor with the formation of an ano-coccygeal raphe and tilting forwards of the coccyx. In fact the tail has been pulled forwards to protect the posterior part of the pelvic outlet. The pelvic aperture together with the pubo-coccygei which still remain as the spincteric portion of the levatores ani are thus displaced forwards and a portion of each muscle now becomes especially adapted as a more efficient sphincter, namely the pubo-rectalis. The pubo-rectalis muscles surround the pelvic aperture not only at the sides but also posteriorly."

Some further confusion regarding the levator ani muscle has followed the conflicting descriptions regarding its splitting or layering as was originally described by Holl and Kohlrausch and just recently re-emphasized by Uhlenhuth. *This detailed splitting has usually been overlooked entirely or disregarded in standard descriptions of this muscle.* According to Uhlenhuth all three components of the muscle—pubococcygeus, puborectalis and iliococcygeus—are layered muscles and he has described, discussed and illustrated these layers in considerable detail in his recent Atlas. Uhlenhuth emphasized that the splitting and differentiation into superficial and deep layers of all three components begins at the origin of these muscles and that both layers are for the most part entirely muscular. This layered arrangement is maintained throughout the diaphragmatic portions as well as throughout the caudal or anal extensions to the visceral outlets, particularly those of the pubococcygeus muscle (figs. 60 and 61).

Courtney also described a splitting or layering of all components of the levator ani muscle into superior and inferior layers. However the splitting or "diverging" occurs at the junction of the muscles with the rectal wall, *posteriorly and laterally. The superior* layer as described by Courtney is a fascial layer formed by "fibers which become fibrotendineus and join with fibers from the levator fascia," while the inferior layer is for the most part fleshy or muscular. As these layers "diverge from each other slightly" they form a V-shaped space along the rectal wall with its open end toward the midline, *"posterior levator space."* Court-

ney considers this space of clinical significance in the deep anorectal infections (for further discussion of this space see p. 210).

The levator ani muscle is at least for the student a difficult muscle to understand. It would seem useful to have an overall concept of the three components of this muscle as closing in the pelvic outlet in two planes—a diaphragmatic and subdiaphragmatic plane.

The diaphragmatic plane or pelvic diaphragm is a broad double-layered sweeping muscular sheet formed primarily by the pubococcygeus and iliococcygeus muscles; the puborectalis contributes but a very small ventral muscle bundle to the pelvic diaphragm.

The subdiaphragmatic plane is formed by the caudal fasciomuscular extensions primarily from the pubococcygeus into the musculature of the visceral outlets particularly that of the anorectal canal.

The puborectalis muscle is the most lateral and dorsal muscular component of the subdiaphragmatic plane and it is separated from the rectal wall by the visceral extensions of the puboanal muscle bundles of the pubococcygeus. So disposed it exercises its strong sphincteric action on the anorectal outlet.

The iliococcygeus muscle has no visceral connections of importance in the subdiaphragmatic plane.

The diaphragmatic muscular plane—the pelvic diaphragm—is for the most part horizontal while the subdiaphragmatic plane

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5 a′, 5 a″, their aponeurotic plates of insertion into ventrum of coccyx; they have been cut away from rectal wall. 6, iliococcygeus, deep layer. 7, coccygeus. 8, origin of puborectalis muscle. 8′, insertion of puborectalis into prostate gland. 8 b, semitubular portion of puborectalis with cranial and caudal fibrous bands of insertion into dorsum of coccyx. 8 c, cylindrical portion of puborectalis. 9, deep division of external sphincter ani with fibrous plate of insertion into dorsum of coccyx. 10, 10, superficial division of external sphincter ani with fibrous plate of insertion into dorsum of coccyx. 11, subcutaneous division of external sphincter ani with fibrous cord of insertion into dorsum of coccyx. 12′, anal mucosa, caudal flap (transition into skin). 14, most caudal muscle bundle of internal sphincter ani. 15′, anal intermuscular septum (Hilton's white line) with fleshy and fibrous bundles of external longitudinal muscle of anorectum. Gorsch's deep postanal space. (From Uhlenhuth, E.: *Problems in the Anatomy of the Pelvis.* Philadelphia: Lippincott, 1953.)

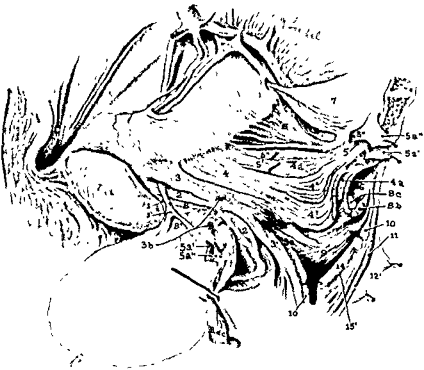


FIG. 61. Deep layer of both diaphragmatic and anal parts. [Scale: 79% (1/1)]. Right half of pelvis. Insertions of prerectal and pubo-anal components of pubococcygeus severed from prostate and rectum. Rectum cut through transversely above the most caudal bundles of *internal sphincter* (14); *aponeurotic plates* of retrorectal muscles (5 a′ and 5 a″) cut away from rectum; rectum pulled forward toward the prostate gland. Cut edges of medial flaps of prerectal (3) and pubo-anal (4) muscles, created at previous step of dissection (fig. 60), returned into apposition with edges of corresponding lateral flaps, and deep layer of both diaphragmatic and anal parts illustrated as one continuous layer. Puborectalis muscle analyzed further (8). 1, 1′, puboprostatic bundles of pubococcygeus. 2, 2, *pubobulbar bundle of pubococcygeus*. 3, *prerectal muscle band of pubococcygeus* exchanging fibers with pubobulbar bundle at point of transition from diaphragmatic to anal part. 3 b, prostatic insertion of prerectal muscle band, cut through. 3′, branch bundle of prerectal band inserted by fibrous cords into ischiorectal fat. 3″, *another branch bundle of prerectal band inserted into deep external sphincter ani*. 3 a, superficial layer of prerectal muscle; only its insertion into the bundle 3″ and deep external sphincter is visible. 4, pubo-anal muscle sheet of pubococcygeus, deep layer; in its anal course it is differentiated into a lesser (4″) and a major (4′) layer, both with fibrous plates of insertion into ventrum (4″) and tip (4′) of coccyx. 4 a, 4 a, superficial layer of pubo-anal muscle bared partly by reflection of retrorectal muscle bands (5′ and 5″). 5′, 5″, retrorectal muscle bands of pubococcygeus, and



FIG. 62. The pelvic origin of the levator ani muscle. A, sacral promontory; B, sacral plexus; C & C, arcus tendineus (white line); D, levator ani; E, coccygeus.

assumes a more or less vertical axis as the caudal extensions funnel around their respective visceral outlets in the pelvic aperture.

The iliococcygeus muscle may be considered almost entirely a diaphragmatic muscle situated nearly at right angles to the long axis of the pubococcygeus. Near the posterior midline it fuses into the posterior extensions of the pubococcygeus muscle (retrorectal bundles or muscles of Uhlenhuth) and contributes a fasciomuscular lamina to the levator plate (fig. 61). It has no extensions to the viscera proper.

The coccygeus muscle which is of less surgical importance completes the pelvic diaphragm behind and above the levator ani muscle.

The piriformis, recto-urethralis, recto-coccygeus and rectovaginalis muscles have also been included in this chapter on account of their intimate relation to the levator ani muscle and its musculo-fascial reflections.

Variable retrogressive muscles of no surgical significance commonly arising from the ischium or ischial spine and inserting into the coccyx or sacrum include the ischiosacralis, anterior and posterior, the ischio-spinalis and others which will not be described.

The Pubococcygeus Muscle

Disregarding for the moment individual components and their caudal extensions to the visceral outlets, the pubococcygeus muscle arises from the posterior aspect of the pubic arch on a line extending from the midpubic point to the lower margin of the obturator foramen. This origin, approximately 3 to 4 cm. from the bone and 1 to 2 cm. from the fascial arch or white line of the levator ani muscle, extends on an oblique plane directed slightly upward (fig. 62). From this origin the muscle fibers extend medially but mainly backward, form the medial boundaries of the pelvic aperture, and looping behind the rectum *above* the puborectalis muscle, they form a muscular raphe or plate which inserts into the anterior aspect of the coccyx and lower sacrum. Apo-

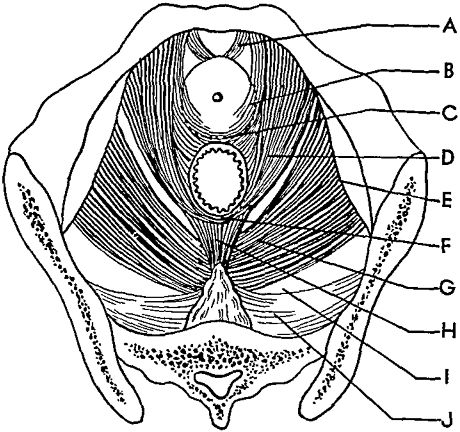


FIG. 64. Visceral extensions of the levator ani muscle. A, extensions to female urethra; B, extensions to prostate or vagina (levator prostatae or vaginae fibers); C, extensions surrounding the rectum (fibers of Luschka); D, pubococcygeus; E, fascial arch (white line); F, puborectalis muscle; G, iliococcygeus; H, levator plate; I, the interval for the ischiococcygeus; J, sacrospinous ligament.

extensions fuse into the longitudinal musculature and capsules of the visceral outlets or bridge the intervals between them. They are of particular significance in gynecologic, urologic and proctologic surgery (fig. 64).

Although variations in the levator ani muscle are common, and the illustrations are that of a selected male specimen, Uhlenhuth has made an important contribution to the anatomy of the pelvorectal musculature, at least from the academic point of view.

The author for practical considerations presents a somewhat simpler if not a strictly detailed academic arrangement of this anatomy.

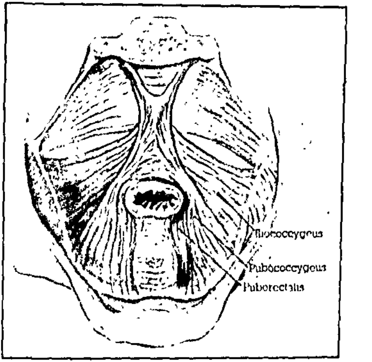


FIG. 63. Pelvic floor from above (After Morgan.)

neurotic extensions from the raphe continue upward on the sacrum as the anterior sacrococcygeal ligaments (fig. 63).

This is the diaphragmatic plane of the pubococcygeus muscle which forms the main muscular component of the pelvic diaphragm. It is covered by the levator (supra-anal) fascia. The subdiaphragmatic plane of the pubococcygeus muscle as previously noted consists of muscular or fibromuscular extensions to the urethra, prostate, vagina, rectum, anal canal, and coccyx.[1] These

[1] The separate muscle bundles of the pubococcygeus to the visceral outlets and the coccyx have been named by Uhlenhuth as puboprostatic, pubobulbar, prerectal, puboanal and retrorectal. These individual muscular extensions have a deep and superficial layer, each of which requires separate description in both its diaphragmatic and subdiaphragmatic or anal plane (figs. 60 & 61).

This anatomy is somewhat bewildering and can only be understood by reference to the detailed descriptions and illustrations by Uhlenhuth in his Atlas, to which the reader is referred.

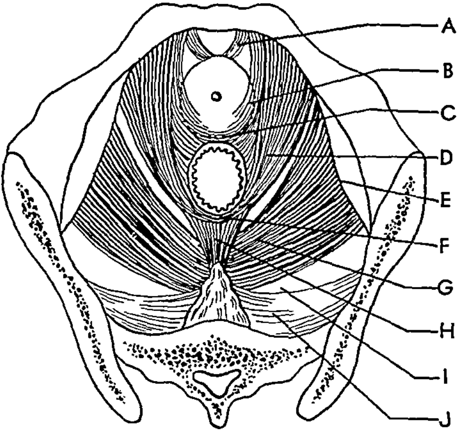


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Visceral Extensions of the Pubococcygeus

Prostate and Urethra

These extensions consist of medial and lateral bundles arising from the pubes near the symphysis. They insert into the medial and lateral surfaces of the prostatic capsule and some of the fibers continue to the prostatic urethra (levator urethrae fibers).

Female Urethra

In the female the medial fibers of the pubococcygeus muscle encircle the posterior aspect of the urethra above the deep layer of the urogenital diaphragm and fuse into its longitudinal musculature. With a superimposed reflection of the supra-anal fascia they form the surgically important pubourethral ligaments (Curtis) or fascia etc. (fig. 110).

Vagina

In the female, pubococcygeal extensions (pubovaginal fibers) insert along the infero-lateral aspect of the vaginal wall and, together with the firm attachment of the levator ani muscle to the deep layer of the urogenital diaphragm, they form the important surgical unit in perineal repair.

Anorectal Junction and Anal Canal

The muscular extensions of the pubococcygeus muscle to the anorectal junction and the anal canal are of particular interest to the proctologist.

Inserting into the intrinsic musculature of the rectum and anal canal they form an integral component of the anorectal muscle ring and the conjoined longitudinal muscle of the anal canal.

They may be conveniently and simply divided into anterior, lateral and posterior bundles.

The anterior bundle (*prerectal muscle of Uhlenhuth*) passes caudally between the rectum and prostate or vagina and at the level of the anorectal junction it extends over the anterior rectal



FIG. 65. The levator ani, including the ischiococcygeus, has been exposed from the posterior margin of the triangular ligament to the sacrospinous ligament. Note particularly the changing direction of its fibers as they sweep from the pelvic wall to their successive insertion into the "levator plate" and the lateral sacrococcygeal fascia. The intimate relation of the profundus portion of the external anal sphincter to the puborectalis muscle is well shown. A, anal canal; B, anal musculature; C, triangular ligament; D, puborectalis muscle; E, pubococcygeus; F, iliococcygeus; G, coccyx; H, ischiococcygeus; I, sacrospinous ligament.

wall as a distinct muscle band which fuses with the deep portion of the external anal sphincter muscle to form the anterior half of the anorectal muscle ring (sphincter recti of the older anatomists). Some of its fibers insert into the longitudinal musculature of the rectum and with reflected fascial extensions from the levator fascia form the anterior fibers of the conjoined longitudinal muscle of the anal canal. The remaining ventral fibers of this anterior bundle insert into Denonvilliers' fascia and finally into the perineal fat. They lie in close proximity to the so-called lateral portions of the recto-urethralis muscle with which they may be readily confused.

In the female this anterior bundle also forms a component of the anorectal muscle ring and the conjoined longitudinal muscle of the anal canal. Its terminal fibers fuse into the perineal body in the caudal recess of the rectovaginal (retrovaginal) space.

THE LATERAL BUNDLE of the pubococcygeus (puboanal muscle—Uhlenhuth) surrounds the anorectal junction directly above the deep external anal sphincter muscle to which it is attached. It extends posteriorly from the anterior bundle and loops around the anorectal kink above and posterior to the puborectalis muscle and forms the main muscular lamina of the levator plate. Similar to the anterior bundle some of its fibers blended with fascial reflections from the levator fascia fuse with the longitudinal musculature of the anal canal and form the conjoined longitudinal muscle (fig. 43).

It may be noted that the supra-anal fascia (diaphragmatic fascia) has an anal reflection in addition to its main layer covering the superior surface of the pubococcygeus muscle and its extensions to the sacrum and coccyx. This fascial arrangement affords a bony insertion for the conjoined longitudinl muscle of the anal canal and integrates the pars analis recti and anal canal musculature into the pelvic diaphragm.

POSTERIOR BUNDLE. The posterior extensions of the pubococcygeus muscles consist of musculoaponeurotic (retrorectal bands—Uhlenhuth) plates by which the fleshy fibers of the pubococ-

cygeus and to a less extent the puborectalis and iliococcygeus muscles are inserted into the coccyx and lower sacrum—the anterior sacral ligaments. These laminated musculofascial extensions form the levator plate, a strong support for the pelvic viscera (fig. 65).

The lateral and posterior extensions of the pubococcygeus in the female are essentially the same as in the male.

It may be stressed that a lengthening and broadening of the pelvic aperture with a corresponding descent of the levator plate impairs the integrity of the pelvic visceral outlets and predisposes to descensus and procidentia of the viscera, particularly in the female.

The Puborectalis Muscle

The puborectalis muscle lies almost completely in the subdiaphragmatic plane. It forms but a very small part of the pelvic diaphragm. At its pubic origin and over the upper layer of the urogenital diaphragm (the superior urogenital fascia), to which it is firmly attached, it is the most medial portion of the levator ani muscle and is not always readily defined as a separate muscle at this point. As it passes horizontally backwards on either side of the pelvic aperture it gradually comes to lie somewhat caudal and lateral to the anal extensions of the pubococcygeus muscle. Becoming distinctly fleshy and broadening out, it undergoes a partial twist on its long axis. During this twist or partial rotation its original horizontal surface becomes its inner surface and its original medial edge its inferior margin. Behind the anorectal junction, ventro-caudal to the looping fibers of the pubococcygeus muscle, the twist is complete and the puborectalis forms a distinct and important sling-like muscle at the level of the anorectal kink (fig. 63). It lies immediately above the upper margin of the deep external anal sphincter muscle to which it is usually attached (fig. 33). This partial rotation of the two layers of the puborectalis muscle on its long axis in order to form a loop around the posterior

aspect of the anorectal junction probably accounts for the peculiar "semitube"-like configuration described by Uhlenhuth (fig. 33). A very thin fascial plate extends from the upper margin of the puborectalis muscle to the coccyx. This forms the caudal lamina of the levator plate and the roof of the deep postanal space. The puborectalis, similar to the pubococcygeus muscle, gives off fibromuscular extensions to the prostate (vagina) and ventral rectal wall contributing to the anterior half of the anorectal muscle ring above and medial to the deep external anal sphincter muscle.

The puborectalis approximates the anorectal junction to the pubes and it has an independent powerful sphincteric action on the anorectal junction.

The puborectalis is better developed in the female. Moreover the entire levator ani muscle is more extensive and admits of much greater mobility than in the male.

The Iliococcygeus

This is one of the more retrogressive muscles of the pelvis and is hence the most variable of the levator ani components.

The iliococcygeus or iliac portion of the levator ani muscle arises from the reflected fascia over the obturator internus muscle, extending from just behind the obturator foramen downward and backward to the ischial spine. This origin is about 4 cm. long but quite variable (fig. 62).

Occasionally its pelvic origin may consist of a tendinous arch spanning the underlying obturator muscle and forming a rather large hiatus—"hiatus pelvicus lateralis" (Schwalbe). This arch may extend to the pubic bone which is sometimes described as part of its origin.

Its muscular fibers, intermingled with aponeurotic reflections from its fascial origin (the white line of the levator ani), are directed inward and downward. They converge somewhat and are inserted into the "levator plate" conjointly with, but below, the flat tendons of the pubococcygeus (retrorectal components). There

is still some difference of opinion as to whether or not any of the fibers of the iliococcygeus terminate in the rectal wall. In our dissections we have observed that the iliococcygeus is distinctly musculofascial below the rectum, the muscular strands being more or less alternated by the fascial which finally fuse into its tendinous attachment in the "levator plate."

As a result of the forward inclination of the pelvis the fibers of the iliococcygeus, as noted by C. N. Morgan, form the posterior arching roof of the ischiorectal space before inserting into the levator plate and few if any of its fibers reach the rectal wall. The pubococcygeus and puborectalis muscles with the subjacent portions of the external anal sphincter muscle form the inner wall of the ischiorectal space (fig. 93).

From the surgical standpoint this portion of the levator is of little importance for either the proctologist or the gynecologist. It forms part of the pelvic diaphragm and supports the levator plate in the act of defecation and in increased abdominal pressure.

Functions of the Levator Ani Muscles

The combined levator ani muscles fix the pelvic floor and act as a fulcrum against which increased abdominal pressure may be exerted in the acts of lifting, coughing, defecation, urination, coition and other perineal activities. As important components of the anorectal muscle ring and conjoined longitudinal muscle of the anal canal the pubococcygeus and puborectalis muscles complement and synergize the contraction and relaxation of the anorectal sphincters.

The puborectalis fibers also assist the anal musculature in completing the act of defecation. Their contraction approximates the rectum and vagina to the symphasis pubis and by narrowing and shortening the pelvic aperture they exert a strong sphincteric action on these visceral outlets. The supplementary action of these muscles to the anal sphincters is of profound surgical sig-

nificance. The iliococcygeus supports and elevates the pelvic diaphragm. It has no sphinctric action on the viscera.

The muscles per se have some supportive function, but it is essentially their related fascial extensions which afford the main support to the pelvic diaphragm. The "ano-coccygeal raphe"—levator plate—extending more or less horizontally from the anorectal junction to the coccyx and sacrum presents an important support to the rectal ampulla, the uterus and vagina.

The levator ani muscle receives its innervation via the second, third and fourth sacral nerves mainly through the middle and inferior hemorrhoidal nerves.

The Ischiococcygeus (Coccygeus) Muscle

The ischiococcygeus or coccygeus completes the muscular portion of the pelvic diaphragm. Since it is covered with the same fascial planes from the pubococcygeus and iliococcygeus its description in conjunction with the levator is necessary to the proper conception of the pelvic diaphragm, perirectal spaces and the fascial reflections over the sacrum. The ischiococcygeus meets the iliococcygeus at almost a right angle.

The muscle arises from the ischial spine and the adjacent sacroiliac fascia. Extending fanwise and becoming rapidly tendinous, it inserts into the sides of the coccyx, the lower sacrum and the medial portion of the sacrotuberous ligament. It is approximately 2 cm. wide at its origin and 5 cm. wide at its insertion. Its posterior margin is continuous with the inferior margin of the piriformis muscle, at which point the splitting of the pelvic fascia is similar to that along the arcus tendineus or white line of the pelvic cavity anterior to the ischial spine. The tendinous arc is actually continuous entirely around the pelvic wall, but of course at different levels (fig. 62).

Behind the ischial spine the arcus tendineus marks the junction of the supra-anal fascia (upper layer of the pelvic diaphragmatic fascia) with the infra-anal fascia (lower layer of the pelvic dia-

phragmatic fascia). The attachment of the arcus tendineus to the sacrotuberous ligament marks the extreme posterior boundary of the ischiorectal space. It also marks the line of separation between the rectrorectal space and the ischiorectal space.

The Piriformis Muscle

The piriformis, a thin triangular muscle, occupies the sacral concavity. It is of proctologic importance largely from the differential diagnostic standpoint of coccygodynia and other painful conditions involving the pelvosciatic region.

Situated below the parietal pelvic fascia, it arises mainly from the bony interval between the second, third and fourth sacral foramina and partly from the sacrotuberous ligament and the fascia overlying and reflected from the sacrosciatic foramen. In the latter situation the muscle fibers are in close relation to the radicles of the sciatic nerve and the possibilities for neuromuscular reflexes are apparent. The muscle extends laterally and leaves the pelvis through the greater sciatic foramen, inserting into the greater trochanter of the femur (fig. 66).

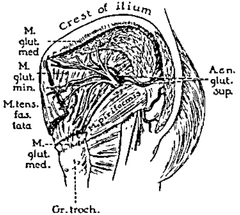


Fig. 66. The piriformis muscle. (Wangensteen, O. H.: *Surg., Gynec. & Obst.*, 1934.)

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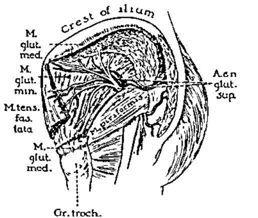


FIG. 66. The piriformis muscle. (Wangensteen, O. H.: *Surg., Gynec. & Obst.*, 1934.)

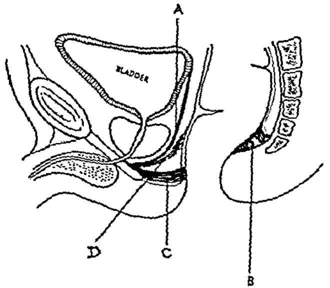


FIG. 67. Relation of the recto-urethralis muscle to Denonvilliers' fascia and to the prerectal space. The rectococcygeus bears a homologous relation to the retrorectal space A, Denonvilliers' fascia; B, rectococcygeus; C, recto-urethralis; D, superior recto-urethralis muscle.

THE RECTOCOCCYGEUS MUSCLE

This is a thin and usually ill-defined band of smooth muscle fibers arising from the longitudinal coat of the rectum. It fuses with reflected fibers from the supra-anal fascia and inserts into the last sacral and first coccygeal vertebrae. It is also described as a thin band of smooth muscle fibers arising from the ligamentum sacrococcygeum anterius and fusing with the longitudinal muscular stratum of the rectal wall. The muscle is quite variable and is considered by some anatomists as a mere variety. It supposedly supports the rectum in the active phase of defecation. The muscle is practically identical in the sexes.

Courtney has expanded this muscle, somewhat. Combining it with fascial extensions from the supralevator or "levator" fascia he describes it as the "iliorectococcygeus muscle," which forms the roof of a so-called "posterior levator space," considered by him as of clinical importance in perirectal suppurative processes (p. 210).

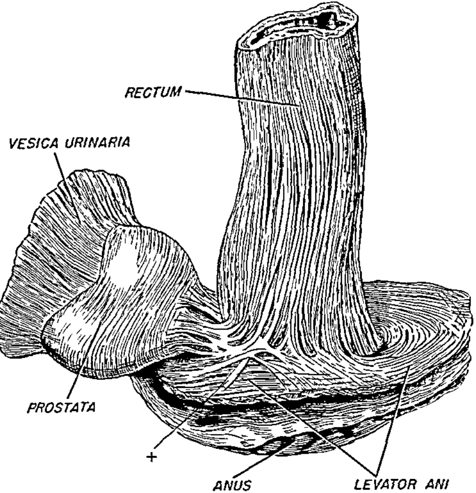


FIG. 68. Showing the muscular connections of the rectum to the prostate gland (lateral portion of the rectourethralis muscle) and the extensions of the supraanal fascia to the longitudinal musculature of the rectum. (Redrawn from Zuckerkandl, Emil: *Atlas der Topographischen Anatomie des Menschen*. Wien: 1900–04.

THE RECTO-URETHRALIS MUSCLE

The recto-urethralis muscle originally described by Kohlrausch in 1854 is also known as the "levator urethra" (Kraus) and "fibers prerectalis" (Testut). This small but surgically important muscle was later described by Roux as a band of smooth muscle fibers arising from the longitudinal tunic of the lower rectum and extend-



FIG. 69. The recto-urethralis muscle. Dissection by author. The urethra has been exposed on a sound just at the posterior margin of the triangular ligament (urogenital diaphragm). The fibromuscular smooth muscle bands connecting the urethra and anterior rectal wall is the recto urethralis muscle.

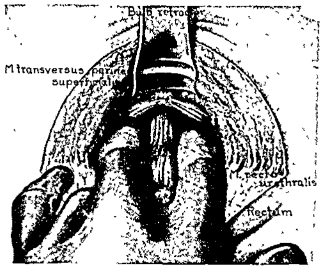


FIG. 70. The recto urethralis muscle. This muscle is not a definitely demarcated structure but merely represents certain fibers of the longitudinal muscle layer of the rectum which insert in the region of the apex of the prostate and hold the rectum in close apposition to its posterior aspect. In the illustration a dotted line shows where the recto-urethralis is split near its insertion, while two fingers of the left hand hold the rectum down out of the way. The recto-urethralis is placed on tension by retracting the urethral bulb anteriorly. (Gibson, T E.: *Surg., Gynec. & Obst.*, 1928).

ing to the prostatic urethra at its junction with the superior layer of the urogenital diaphragm and fusing with the external vesical sphincter (fig. 69 and 70). It spans the deepest recess of the posterior prostatic spaces and is therefore an important landmark in reaching the recto-prostatic cleavage planes. It may readily be confused with the urethral and prostatic extensions from the levator ani muscle (the anterior extensions or prerectal component of the pubococcygeus muscle) (fig. 61).

Elliot Smith describes the recto-urethralis as arising from the anterior aspect of the anal canal rather than the rectum and he prefers the term "ano-urethral" to recto-urethral. He also refers to the smooth muscle fibers which arise from the rectum and insert into the apex of the prostate and the lower aspect of Denonvillier's fascia as the "superior recto-urethralis" muscle (fig. 69).

C. Naunton Morgan also recognizes two recto-urethralis muscles and he describes the "superior one passing downward and forwards toward the base and body of the prostate behind the fascia of Denonvilliers. I have seen the latter muscle in doing a total cystectomy" (fig. 67).

The intimate connection of the anorectum with the urogenital sphincters by this muscle is very significant to postoperative retention.

It may be noted that the recto-urethralis muscle is quite variable and sometimes absent. It is likewise readily confused, as previously stated, with the anterior (prerectal) visceral extensions of the pubococcygeus muscle.

The extensions from the longitudinal muscular tunic (smooth muscle) of the rectum are quite variable in origin and degree of development. This has led to the variety of anatomical descriptions as superior, inferior and lateral recto-urethralis muscles.

In the female the corresponding recto-vaginalis muscle is scarcely ever described.

The Recto-Vaginalis

The musculofascial structure homologous to the recto-urethralis in the female is the rectovaginal muscle which lies in the floor

of the rectovaginal space or "septum." This muscle is still less well defined than the recto-urethralis and, because of the fusion of the musculofascial planes forming the perineal body, it is difficult to recognize and is of no surgical significance.

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CHAPTER V

The Rectum and Sigmoid

Embryologic Considerations

The primitive intestinal tract consists of a more or less straight longitudinal tube supported by a mesentery which extends from the gut to the posterior midline of the embryonic peritoneal cavity. At about the eighth week of embryonic life the intestinal tube forms an anterior loop and becomes differentiated into a foregut, midgut and hindgut which derive their blood supply from the celiac, superior and inferior mesenteric arteries, respectively.

The midgut forms the first extensive loop—the enterocolic loop—between the foregut and the hindgut which is comparatively much shorter than the other segments and which ends in the common cloaca at the caudal end of the embryo. As the enterocolic loop develops the mesentery becomes lengthened and begins to take fixed points of attachment to the posterior abdominal wall between the wolffian bodies or anlages of the kidneys. The duodenum, jejunem, ileum and the right half of the colon develop from the enterocolic loop. The left half of the transverse colon, the descending colon and the sigmoid loop develop from the hindgut.

Owing to the size of the liver, the large enterocolic loops extend more or less parallel and occupy originally the left half of the peritoneal cavity. As development proceeds, the primitive colon lengthens and the bulbous expansion, which has already formed and which corresponds to the cecum, crosses to the upper right side and descends into the right iliac fossa in front of the right

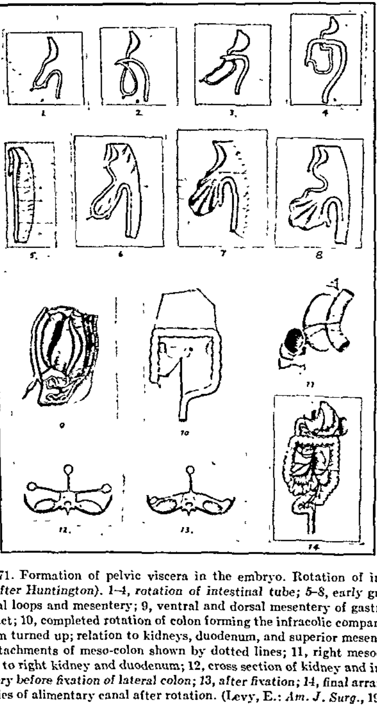


FIG. 71. Formation of pelvic viscera in the embryo. Rotation of intestinal canal (*after Huntington*). 1–4, *rotation of intestinal tube*; 5–8, early growth of intestinal loops and mesentery; 9, ventral and dorsal mesentery of gastro-intestinal tract; 10, completed rotation of colon forming the infracolic compartment—omentum turned up; relation to kidneys, duodenum, and superior mesenteric artery, attachments of meso-colon shown by dotted lines; 11, right mesocolon in relation to right kidney and duodenum; 12, cross section of kidney and intestinal *mesentery before fixation of lateral colon*; 13, *after fixation*; 14, final arrangement of arteries of alimentary canal after rotation. (Levy, E.: *Am. J. Surg.*, 1939.)

kidney. Failure of rotation or descent is occasionally reflected in the adult as a *high-lying cecum or a left-sided appendix.* The rotation is also shared by the iliac coils and usually the ileum enters the large gut from the mesial side. The mesentery rotates around the inferior mesenteric artery and becomes duplicated, its opposed surfaces fusing (fig. 71).

The lengthened colon now becomes fixed in the right and left iliac fossae, and along the posterior abdominal walls; the intervening loop swings across the abdominal cavity as the transverse colon (fig. 71).

In the left iliac fossa from below the point of fixation the colon develops and lengthens medially to form the sigmoid loop. Caudally this loop joins the primitive rectum which retains its fixed mesial position. The folding-over of the mesentery and the axial change from the sigmoid to the fixed rectum tends to angulate the rectosigmoid junction, a fact well appreciated in the sigmoidoscopic examination of the adult. Moreover, the fixation of the colon in the left iliac fossa gives the root of the mesentery a diagonal slant toward the left side and disposes the sigmoid to varying lengths and abnormal mobility.

Development of the Rectum

The rectum proper has a dual development and embryologically it is commonly divided into pelvic and perineal portions, the former derived from the hindgut above the peritoneal reflection and the latter from the post-allantoic gut below the peritoneum.

In the early embryo the caudal end of the primitive gut ends in the recess of the tail fold—the cloaca—which terminates anteriorly in the allantois. The allantois is initially a continuation of the hindgut but as the caudal curve of the embryo increases it is displaced ventrally with the body stalk and develops into a separate diverticulum from the hindgut. This division of the original cloaca into rectal and urogenital portions becomes increasingly evident and continues *to their final and complete separation.*

As the embryo develops more rapidly in a dorsal direction than

ventrally a small portion of the hindgut comes to lie behind or below the allantois. This is the post-allantoic gut which is the anlage for the ampulla and sphincteric—pars analis recti—portions of the lower rectum in contrast to the true pelvic rectum which develops from the hindgut proper.

As noted by C. Naunton Morgan the junction of the allantois with the hindgut is at the caudal limit of the *body* cavity. This point in the adult is the reflection of the peritoneum from the anterior wall of the rectum to the bladder, vagina or prostate. The level of the peritoneal reflection is therefore the dividing line between the hindgut and the postallantoic gut, and the subperitoneal portion of the rectum represents the post-allantoic gut of the embryo.

This distinction is significant to the commoner congenital anomalies of this region.

Caudally the cloaca is covered by the cloacal membrane lined by entoderm internally and ectoderm externally. It marks the area of the adult perineum and its lateral mesodermal wings contain the anlages of the urogenital musculature. Growth of the embryo caudal to its junction with the cloacal membrane forms the tail enclosing a small portion of the cloaca (the tail gut) which eventually disappears (fig. 72).

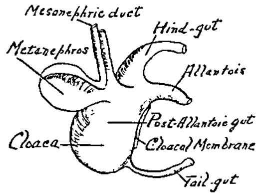


FIG. 72. Early human cloaca showing hind-gut and post-allantoic gut. 7 mm. embryo (approx.)

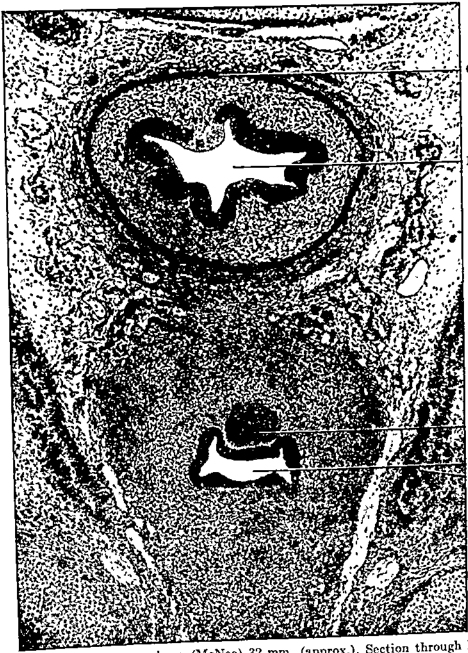


FIG. 73. Human embryo (McNee) 32 mm. (approx.). Section through lower part of rectum below the level of the peritoneal cavity, showing solid cord of epithelial cells formed from fused Müllerian ducts (future vagina) and urogenital sinus (future bladder). (After Harris.) A section through 32-mm. embryo, passing through the lower part of the rectum and urogenital sinus, displays the integrity of the rectal mucous membrane, with no trace of intra-epithelial cysts. The inner circular layer of muscle is already differentiated. The longitudinal muscle can

Cephalad the cloaca is separated from the primitive abdominal cavity by the inferior splanchnopleure covered by peritoneum above and entoderm below. As the splanchnopleure develops cadually it forms the posterior wall of the urogenital cloaca and the anterior wall of the rectal cloaca, enclosing a fold of peritoneum. Fusion of mesodermal walls at the junction of the allantois and hindgut and their projection to the cloacal membrane forms the urogenital or urorectal septum which completely separates the urogenital and alimentary tracts.

The peritoneal folds in the urorectal-urogenital or recto-genital septum are the anlages of the recto-genital or rectovaginal septum in the female; and the rectogenital or prostato-peritoneal fascia of Denonvilliers' in the male. These are important surgical landmarks relative to the prerectal, posterior prostatic, rectovesical and rectovaginal spaces.

The ventral or urogenital portion of the cloaca develops an anterior expansion (the urinary bladder), a medial constriction (the urethra) and a caudal basin (the urogenital sinus). In conjunction with the mesoderm of the pelvic bar, the urogenital sinus forms the lower half of the vagina, the prostate and the seminal vesicles. The fused Müllerian ducts form the uterus, cervix and upper portion of the vagina which becomes continuous with the bulbous expansion (the sinovaginal bulb) from the urogenital sinus, completing the continuity of the vagina and the uterus (fig. 73).

barely be recognized, and there is as yet no trace of the muscularis mucosae. The urogenital sinus is surrounded by a large and actively growing mass of mesoderm in which no trace of muscle differentiation is yet present. The peculiar significance of the late development of the musculature of the bladder, with its peculiar predisposition to diverticulosis, has been considered previously by Harris. Posterior to the urogenital sinus, and invaginating its posterior wall, the "genital stalk," as a solid plug of epithelial cells, displays the area of epithelial occlusion which at a future date will be canalized to form the vagina. This section passes immediately below the rectovaginal pouch of the peritoneal cavity (pouch of Douglas) and indicates clearly the bridge of mesoderm which runs from the anterior aspect of the rectum to the posterior aspect of the urogenital sinus. It is this tissue which in the male forms the recto-urethralis muscle, in the female, the rectovaginalis muscle, as described by Elliot Smith.

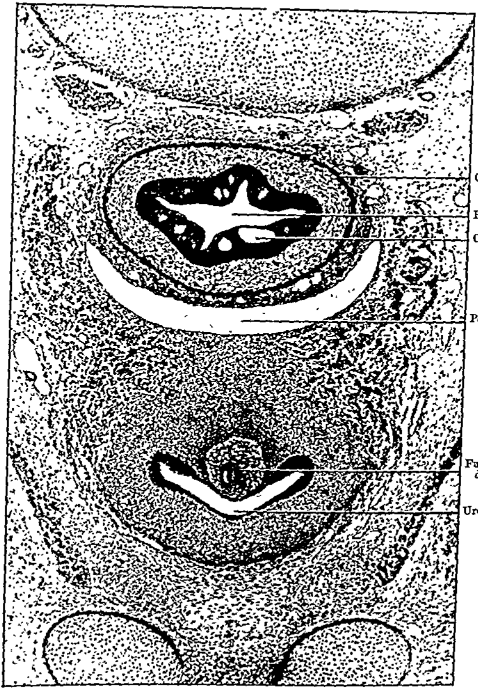


FIG. 74. Human embryo (McNee) 32 mm. (*approx.*). Section through rectum, fused Mullerian ducts and urogenital sinus at the level of the entry of the ureters, illustrating *normal intra-epithelial cyst formation in the rectal epithelium.* (× 80). (after Harris.) Such intra-epithelial cysts, if they persist, may be a fertile cause of proctitis. *This section is of peculiar interest, in that it shows, posterior*

The division of the larger common cavity of the cloaca into a ventral genito-urinary and a posterior rectal anlage by a successively projected septum—the pelvic bar or urogenital septum—readily explains the variety of developmental anomalies possible in this region (fig. 74).

The lumen of the rectum develops normally through the process of epithelial occlusion and subsequent canalization of the surrounding mesoderm. This process is characterized by the formation of coalescing epithelial cysts which have an intramural location and, as emphasized by Harris, may persist in the adult rectum and constitute "a fertile source of proctitis" (fig. 74). The cysts may extend into the anorectal tissues and may be significant in the pathogenesis of stenoses, atresia, diverticula and ectopic cystic formations.

To summarize: The colon develops partly from the midgut and partly from the hindgut and extends from the cecal swelling on the caudal limb of the enterocolic loop to the expansion of the hindgut which forms the internal cloaca. The left half of the colon and the sigmoid develop from the left colic limb of the enterocolic loop, commonly referred to as the hindgut, which becomes continuous with the cloacal rectum (fig. 71).

The pelvic portion of the rectum develops from the hindgut; the ampulla and sphincteric portion above the anorectal line from the post-allantoic gut.

The Rectum

Anatomists differ concerning the exact extent of the rectum. That portion of this organ covered by peritoneum is sometimes described as part of the sigmoid colon.

to the urogenital sinus (primitive bladder), the fused right and left müllerian ducts, one of which has not yet lost its lumen. The two Müllerian ducts fuse and the lining epithelium proliferates and forms a solid plug of epithelium which at a later stage will be canalized to form the upper portion of the vagina. The epithelial plug or "genital stalk" is surrounded by actively prolferating mesoderm which is delineating the muscular wall of the vagina. The firm attachment between the adult vagina and bladder is thus clearly indicated in the embryo.

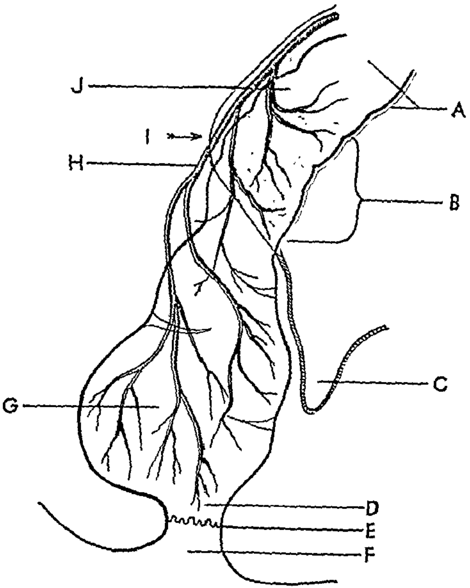


FIG. 75. Peritoneal relations to the rectosigmoidal junction. A, peritoneum; B, rectosigmoidal junction; C, peritoneal culdesac; D, sphincteric portion of rectum; E, anorectal line; F, anal canal; G, ampulla; H, superior hemorrhoidal artery; I, level of 2–3 sacral vertebrae; J, *mesorectum*.

For practical purposes the rectum may be described as extending from the level of the third sacral vertebral body to the anorectal line (fig. 75). The surgery of the rectum usually involves the sigmoid and a definite line of demarcation seems unnecessary. As emphasized by Tuttle, the level of the third sacral vertebra corresponds to the termination of a definite mesentery; it marks the point at which there is a change in the blood supply; it is the level at which the taenia of the sigmoid spreads out to reinforce the longitudinal muscle coat of the bowel; it corresponds to the site of rectal narrowing to join the sigmoid; finally it marks the change in the color, capillary pattern and rugosity of the rectal mucosa. The upper limits of the rectum vary to some degree in the sexes.

The rectum has also been divided into upper and lower segments: the prostatic and sacrococcygeal (Tuttle); the pelvic and perineal or sphinctoric (Waldeyer). From the functional and endoscopic points of view, it may be conveniently divided into sphincteric and ampullary portions; the ampullary or ampulla extending from the third sacral vertebra to the pelvic diaphragm at the insertion of the levator ani muscle. This point in the male is roughly opposite the lower end of the prostate and in the female about the middle of the vagina. It also corresponds to the termination of the flexura sacralis of the rectum.

The sphincteric portion of the rectum is surrounded by the levator ani muscle, the supra anal fascia and the fascial collar of the conjoined longitudinal muscle. It is sometimes considered as the upper part of the anal canal.

Measurements

The rectum is usually described as varying from 10 to 15 cm. in length, its upper limits, as noted, being variable. In the female it is somewhat shorter. The size of the individual modifies these measurements. The circumference varies from 15 cm. at the rectosigmoidal junction to 35 cm. or more at its widest ampullary portion, decreasing again at its junction with the anal canal. The

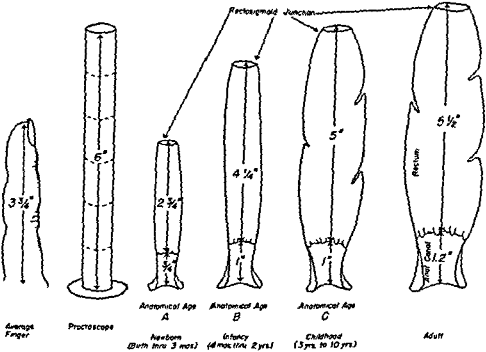


FIG. 76. A comparative chart of the rectums and anal canals of the three stages of growth of the child and adult. An average finger and a six inch proctoscope are used as a scale to indicate the respective heights reached at the various ages. X, the Houston valves. Note their absence in anatomical ages A and B. Also note that the rectosigmoid areas in ages A and B are about the same circumference as the upper rectum. (After Shapiro.)

diameters of the rectum are extremely variable and depend, in the living, on the intra-abdominal pressure. They are of no practical significance. All of the above figures are subject to great variations in pathologic conditions.

In infancy and childhood the configuration of the rectum is greatly influenced by the development of the bony pelvis. According to Shapiro the rectum in the newborn is approximately half the length of the adult rectum, averaging 2¾ inches. During early infancy it increases ¼ to ⅓ in length, averaging 4¼ inches. From three years to the end of the first decade its rate of growth is much less rapid, increasing again in the second decade to reach adult proportions (See fig. 76 for details).

Conformation

When empty the rectum, like the vagina, presents itself as a more or less transverse slit, the anterior wall approximating the posterior when the viscus is empty. It may be observed in this respect that the size and form of the ampulla vary at different times in the same individual, as is commonly verified by roentgen-ray studies. The ampulla may be roughy pear-shaped, thyroid- or balloon-shaped, as demonstrated by the casts of Quenu and Hartmann (fig. 77).

Longitudinally the rectum in general conforms to the sacral curve. Its anterior wall is straighter in contrast to the posterior wall of the ampulla which is directed anteriorly somewhat ab-

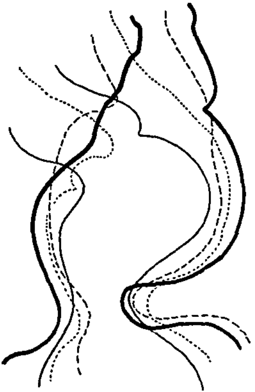


FIG. 77. Superimposed outlines of casts of the rectum. The solid black line represents the outline of the common adult pattern. (After Quenu and Hartmann.)

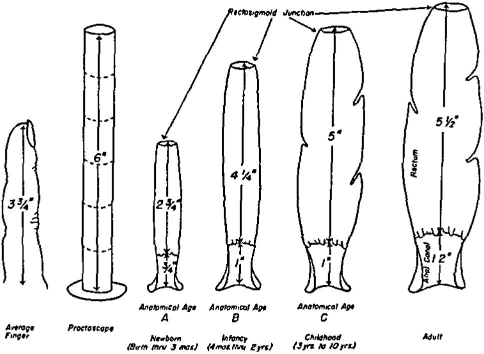


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may be observed. In line with its increased vascularity, the rectal mucosa has a particularly well-developed glandular apparatus consisting of mucigenous tubular glands (Lieberkühn), characterized by an abundance of goblet cells which give a characteristic honeycomb-like appearance on histologic section (figs. 78 and 79).

The epithelial surface of the rectal mucosa is covered by a layer of stratified columnar cells which may assume a more cuboidal shape at the lower end of the rectum at its junction with the squamous or stratified squamous epithelium of the anal canal (anoderm). In addition to the simple glands of Lieberkühn the rectal mucosa contains abundant lymph follicles situated between the glands. Lymph nodules or larger collections of the follicles may form definite Peyer's patches. The syncytial or intrafollicular tissues between the glands convey the lymphatics, nerve plexuses and vascular supply (fig. 80).

At the anorectal junction are found glands which are peculiar to the esophagus, duodenum and rectum—the intramuscular or anal intramuscular glands. According to Harris, these glands grow deeply during embryonic development so as to reach the circular muscle layer before the muscularis mucosae is differentiated; in the adult, therefore, they retain their deep intramuscular position. Extending deep to the mucosa they have an important proctologic and pathogenic implication. These glands have been described at some length in Chapter II.

The Submucosa

The submucosal layer of the rectum, particularly that underlying the columns of Morgagni in the sphincteric portion of the rectum, is of special interest. In this region the bulbous terminals of the superior hemorrhoidal arteries and veins ramify in a supportive syncytial network of elastic and connective tissue forming the internal or superior hemorrhoidal plexus—the annulus hemorrhoidalis. This arrangement permits of considerable mobility in this area and at the same time predisposes it to arteriovenous dilatation, redundancy and hypertrophy of its interstitial tissue—

ruptly in a more or less horizontal plane over the ano-coccygeal raphe-levator plate. This somewhat abrupt directional change forms the "blind spot" of the rectum.

The anterior wall in the female follows the posterocephalic direction of the vagina.

The rectum also presents lateral curvatures or flexures which may be quite prominent and which correspond to the indentures opposite the rectal valves (valves of Houston). Although variations are common, there are usually two flexures to the right and one to the left. At its upper end the rectum narrows again and there is usually a definite angulation or fold of the gut wall at the rectosigmoidal junction which, however, is not (at least embryologically) the same as the indentations in the rectum proper. These axial changes are significant in the endoscopic examination of the sigmoid. Accentuation of the curves and indentations shortens the rectum while their obliteration lengthens it.

The ampulla at times assumes a more or less tubular form which may be the result of interstitial fibrosis following chronic inflammatory processes. In infancy and childhood the rectum is more or less cylindrical in shape retaining to some extent its embryonic form which predisposes it to intussusception and prolapse. The bulbous ampullary shape of the rectum in the adult provides a certain degree of positional support and allows for accommodation of the content and expansion of adjacent organs.

The adult rectum has four well-defined coats: the mucous, submucous, muscular and serous; these are somewhat modified by its extraperitoneal and intrapelvic location.

The Mucosa

The mucous membrane is thicker, darker in color (in comparison to the salmon pink of the sigmoid), and somewhat more richly vascularized, predisposing it to hemorrhagic disease. The mucosa presents a greater degree of mobility in the rectum and sometimes the formation of large rugous folds, referred to as pseudopolyps,

may be observed. In line with its increased vascularity, the rectal mucosa has a particularly well-developed glandular apparatus consisting of mucigenous tubular glands (Lieberkühn), characterized by an abundance of goblet cells which give a characteristic honeycomb-like appearance on histologic section (figs. 78 and 79).

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Fig. 78. The rectal wall. Note the well-developed submucosa, the glands of Lieberkühn and the solitary agminated follicle. The muscular layers are also well differentiated. A, rectal mucosa; B, submucosa; C, rectal glands (Lieberkuhn); D, agminated follicle; E, circular muscle coat; F, longitudinal muscle coat.

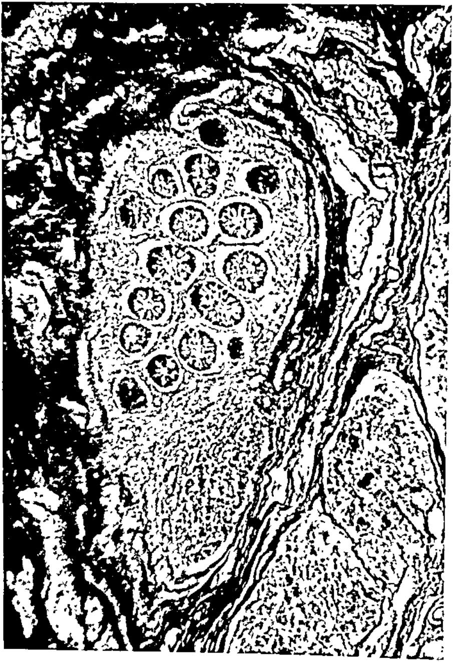


Fig. 79. Magnification of fig. 78, showing glands of Lieberkühn and agminated follicle.

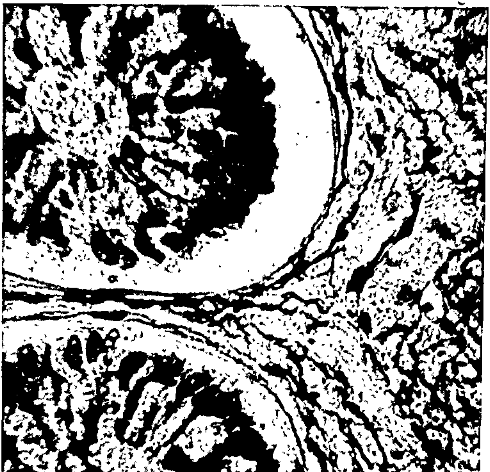


Fig. 80. Further magnification of fig. 79. Note the interglandular network of supportive tissue, nerve fibrils, and the honeycomb like arrangement of the goblet cells.

the combined pathologic components of internal hemorrhoids. The submucous layer also contains a fine stratum of longitudinally disposed muscle fibers (the muscularis mucosae) particularly well developed in the annulus hemorrhoidalis. The submucosa is particularly rich in lymphatics and terminal nerve fibers and plexuses (fig. 80). The free mobility of the mucous membrane over the region of the annulus and its seeming capacity for comparatively large amounts of hemorrhoidal injection solutions have led to terming this zone, clinically, the submucous space (page 184).

The Musculature of the Rectum

The rectum, like the colon, has inner circular and outer longitudinal layers of muscle. However, their disposition has a peculiar and distinctive arrangement.

The internal circular layer has a wing-like arrangement in which successive muscular bundles sweep fanlike from the indentations corresponding to the valves over the lateral bulb-like expansions of the rectum. These fibers appear to be more or less attached at the valvular indentations. Small irregular bundles of fibers from the internal layer extend to the outer muscular coat and seem to fuse with it (fig. 81). This arrangement is similar to that found in the hollow viscera (stomach, urinary bladder, etc.). At its lower extremity, about 3 to 4 cm. from the anal verge, the internal muscle becomes thicker and finally terminates in the well-defined internal anal sphincter which is partially encircled by the deeper layers of the external anal sphincter (see Chapter III).

The outer longitudinal muscular tunic of the rectum is formed by an expansion of the colonic taenia at the termination of the sigmoid colon. The expansion and attenuation of the taenia form a more or less diffuse fibromuscular coat which continues down on the rectum as definite anterior and posterior bands. These become more muscular at the anorectal junction and fuse with the rectococcygeus, recto-urethral and rectovaginal muscles.

Irregular connections between the two coats of the rectal musculature are formed by arched muscular fasciculae extending

prominently to and from the longitudinal bands. It would appear that these fibers supplement the action of the longitudinal muscle band; however, their exact function is not clearly understood.

The irregular "joined arch"-like arrangement of the rectal musculature just described increases its functional capacity, and the rectal valves appear to be points of anchorage for muscular co-ordination.

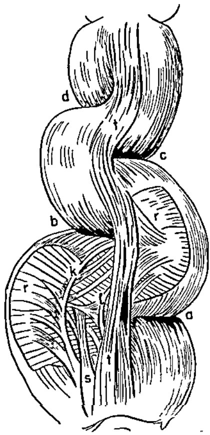


FIG. 81. The longitudinal and circular muscular coats of the rectum (After Laimer). Note that the superior rectal valve does not correspond to the rectosigmoidal junction. a, b, and c, indentations of the valves; d, *rectosigmoidal flexure* fold; R, circular muscle coat; k, l, and s, extensions from the longitudinal muscle coat to the circular; t, the continuation of the colonic tineal band. (Levy, E.· *Am. J. Surg.*, 1939.)

At the level of the pelvic diaphragm the outer muscular wall of the rectum is joined by the fibro-elastic extensions from the levator ani muscle to form the important conjoined longitudinal muscle of the anal canal. Some of the levator extensions extend upward on the rectal wall with the supra-anal fascia; but the bulk of them, forming a well-defined collar, reinforce the longitudinal muscle and continue downward to become integrated into the anal canal and its musculature. The mixture of striated and smooth muscle fibers is readily observed in histologic sections of the anal canal.

It is essentially through this fasciomuscular arrangement that the levator ani muscle exerts its important complementary activity and control on the anal musculature and the perineum (Chapter III, page 71).

The Serous Coat

The peritoneal coat is continued from the sigmoid and reflected over the anterior surface of the rectum and into the interval between the bladder and uterus, forming the rectovesical or uterine pouches. The depths to which the reflection extends is variable and depends somewhat on the size and sex of the individual, the degree of distention of the rectum and the adjacent bladder and uterus. Pathologic descent or elevation of these organs varies the height of the peritoneal reflection above the perineal level, which may be an important consideration in surgery of the pelvic viscera. The usual distance of the peritoneal cul-de-sac above the anus is 7 cm. in the male and 4 cm. in the female.

Laterally the peritoneal folds are reflected diagonally upward and backward to form the pararectal fossa and the leaves of the mesorectum and sigmoid. Anteriorly they form the paravesical fossa.

The Rectal Valves

In addition to the normal rugous folds of the mucosa, the rectum presents an inconstant number of crescentic plications



FIG. 82. Usual location of Houston's valves. White dotted line shows height to which the peritoneal culdesac is raised when bladder is distended. (Tuttle, J. P.: *Diseases of the Anus, Rectum and Pelvic Colon*. D. Appleton, 1906.)

which have a definite structure, including the circular muscle coat of the bowel wall (fig. 82). Although referred to many times in the literature since their original notation by Morgagni, they were first carefully described anatomically and functionally, as valves, by Houston and since then they have assumed an unwarranted importance in proctologic literature and practice. Gant considered them a fertile source of obstruction, important in many cases of constipation and proctostasis, and devised a special technic for their prompt ablation.

In the strict sense they are not valves, and the degree to which

they are able to function as such is still somewhat debatable. Sometimes they are absent. Their close anatomic association with the musculature of the rectal wall is deserving of more than passing notice.

The valves are quite variable in number, location and degree of development. Crescentic in shape, their attachment occupies roughly one-half to two-thirds of the circumference of the rectum. Usually there are three, an inferior, middle and superior. At times there are five. The middle valve, usually more prominent and

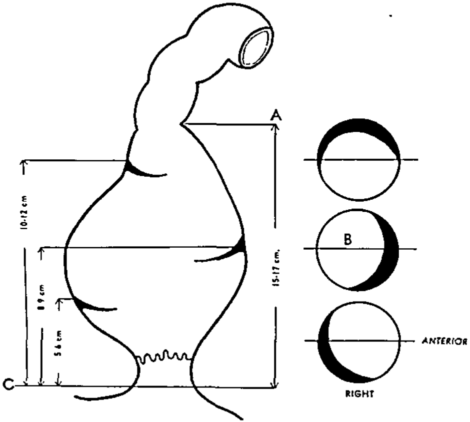


FIG. 83 The rectal valves—average distances above the intersphincteric line. Right figures: their relative location in the rectal circumference. The middle valve is the more constant and more prominent valve. Note that the upper valve should not be confused with the rectosigmoidal junction. A, rectosigmoidal junction; B, middle valve; C, intersphincteric line.

more constant in location than the others, is situated over the base of the bladder, or a little to the right, about 5 to 9 cm. above the anal verge. It is commonly referred to as the plica transversalis of Kohlrausch, and it bears a fairly constant relation to the depth of the peritoneal cul-de-sac, as mentioned by Tuttle and observed by Testut, Otis and Kohlrausch (fig. 83).

The inferior valve is usually located in the left posterior quadrant, from 1 to 1½ inches (25 to 32 mm.) above the anal verge. The superior valve lies 3 to 4 cm. above the middle valve. Above the superior valve is the prominent and sharp angulation sometimes formed by the rectosigmoidal junction which, although it forms a valve-like fold of the sigmoidal wall, is quite different in structure and muscular relation from the rectal valves from which it should be carefully distinguished. The questionable increase in the musculature of the bowel wall at this point has been repeatedly referred to as the third sphincter (O'Beirne).

In comparison to the insignificant rectal valves the rectosigmoidal fold or junction is of considerable proctologic significance. Owing largely to its angular conformation and its mesenteric attachment, it assumes importance, physiologically, in collecting the feces in the sigmoid, and is a significant etiologic factor in functional as well as organic constipation (proctostasis or dyschesia). Its obstructive features in endoscopic examination of the sigmoid have led the author to modify the usual technic of sigmoidoscopy.

Histologically the valves have the same structure as the remainder of the rectum, with the exception of the longitudinal coat which spans the base of the valve, in contrast to the circular muscle coat which is well developed in the base of the valve and extends well out to its free margin (fig. 84). The interval between the reflections of the circular muscular strata into the valve is filled with fibrous connective tissue which increases its structural integrity. The mucosa is described as being particularly rich in the follicles of Lieberkühn, and the muscularis mucosae is more developed than elsewhere in the rectum.

Supported by Houston's original description and the investigations of Pennington, the valves are repeatedly ascribed the function of producing a rotary and supportive action to the oncoming feces. In view of their extreme variations in number, location and development, together with the varying consistency and length of the fecal mass, one may question the degree of their efficacy in this capacity. Furthermore, the valves do not always appear to prevent the migration of even formidable foreign bodies to the upper colonic regions and their activity in the retroperistaltic activity of the rectum has not yet been fully described. In only rare instances do the valves produce sufficient obstruction to warrant their surgical division or partial removal.

These valves are probably a part of the intrinsic muscular pattern of the rectum and contribute a completive action to the contraction of the rectal musculature and act in a manner similar

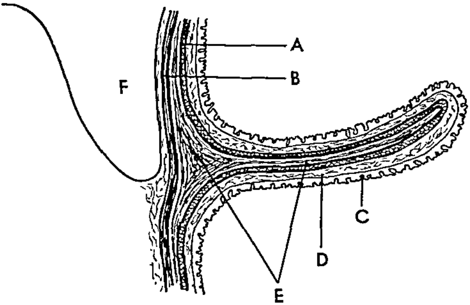


FIG. 84. Longitudinal section of the rectal valve (schematic). Note the accentuation of the circular muscle fibers and the rather dense fibro-areolar reticulum at the base of the valve. A, circular muscle; B, longitudinal muscle; C, mucosa; D, submucosa; E, fibro areolar tissue; F, culdesac.

to the deeper haustral contractions of the colonic wall holding the fecal mass analward in its peristaltic activity. In atony of the rectum they are attenuated and ill-defined.

The Third Sphincter (Sphincter of O'Beirne)

At a distance varying from 1 to 2 inches above the upper valve, the lumen of the rectum decreases in caliber to conform with that of the sigmoid: the rectosigmoidal junction.

The changes in the blood supply, rugosity and color of the sigmoidal mucosa correspond to the zone of narrowing which seems to have been well established by the investigations of Reeves, as quoted by Mayo and referred to by Buie. Reeves, in an investigation of 46 cadavers, found "a terminal constriction in 80 per cent of the cases and . . . in 2 instances the narrowing was so definite as to reduce considerably the caliber of this portion of the bowel."

At the site of the narrowing a more or less definite increase in the circular muscular coat of the bowel is regularly described and this has been referred to as a third sphincter (O'Beirne), having a special function in the act of defecation. Hyrtl and others have also considered this as a true sphincter.

On the other hand, the presence of any definite increase in the muscular coats of this region of the bowel has been denied by Martin and Burden, at least as being uniformly present. The question as to whether there is a true rectosigmoidal sphincter muscle appears to be still unsettled.

A study of the literature on this point is amusing, contradictory and inconclusive, and one is surprised at the variance in the anatomic descriptions of an area so readily accessible. Including O'Beirne, whose name is usually connected with a third sphincter, Sappey, Nelaton, and Velpeau, among others, have described this sphincter. Kelsey, Otis and others have as vigorously denied its existence. The majority of authors remain noncommittal on the subject.

It appears that in some instances the upper rectal valve has

been confused with the actual rectosigmoidal junction which may extend over a distance of 2 or 3 inches. It is likewise not unreasonable to assume that the irregular muscular arrangement of the inner circular muscle coat of the rectum may also be found at its junction with the sigmoid; furthermore, by the usual angular junction of the rectum with the sigmoid, a musculo-mucosal fold is formed which is quite similar in appearance to the rectal valves.

Clinically, there seems to be little doubt that in the majority of cases there is a definite narrowing of the gut at the point of the usual angular junction which, irrespective of any increase in the muscular walls, might be considered as having some sphincteric or valve-like action. However, no definite sphincter, e.g., in the sense of the internal sphincter ani, is present.

With the change in bowel function from the sigmoid to the rectum, there is undoubtedly an increase in the number of muscular fibers as is commonly observed at all embryonic junctional areas. The conclusion, however, that the rectosigmoid has a true sphincter, as commonly understood, does not appear to be tenable. It is possible that a sphincter-like action may be ascribed to it.

The Supports and Fixation of the Rectum

The proctologic literature is in more or less accord with the descriptions of the fixation and supports of the rectum as described by the leading textbooks on anatomy. However, in the complex and confused clinical classification, as well as in the variegated surgical and injection forms of therapy for prolapse and procidentia of the rectum, the anatomy becomes somewhat accommodative to the therapy. It is noteworthy in passing that Curtis in his excellent description of the pelvic fascia of the female states that "except for its peritoneal investment and the hemorrhoidal vessels, the rectum, in so far as observed in the present study, is without special ligamentous supports." It may be also noted that the so-called lateral ligament of the rectum, which is seemingly confused in the surgical and proctologic literature and is referred to as different supportive structures, requires elucidation.

The lateral stalks of Jonesco are sometimes *referred to* as the lateral ligaments of the rectum. However, these stalks are rather posterior than lateral. We rather agree with Morgan who states that "the lateral ligaments of the rectum are, I think, very difficult to describe since they are nothing more than a condensation of connective tissue passing toward the bowel along the middle hemorrhoidal vessels and nervous tissue running toward the rectum" (fig. 85).

Furthermore, the idea entertained concerning the upper limits of the rectum and finally the conception that prolapse and procidentia are hernias have an important bearing on this subject.

The supports of the rectum as described in this work may be conveniently divided into the fixed and mobile; the former are found at the rectosigmoidal junction or upper rectum and the latter at the junction of the ampulla and sphincteric portions. The upper supports include the mesorectum, its vessels and fibrous sheaths, the visceral fasciae of the supra-levator and retrorectal spaces with their more or less ligamentous attachments to the remaining pelvic viscera. In the supralevator space the lateral ligament (q.v.) forms the more important supportive structure, while in the retrorectal space the so-called rectal stalks afford some degree of support. Although the peritoneal reflections are sometimes described as ligaments for the rectum, their function in this regard is probably insignificant.

Strong supports for the ampulla are the levator plate and the fascia of Waldeyer. The latter is a continuation of the posterior parietal fascia from the sacrum along the posterolateral aspects of the rectum and over the adjacent coccygeus muscles. In perineal excision of the rectum and in order to gain the retrorectal as well as supralevator spaces it is necessary to completely divide this winglike layer of fascia.

The sphincteric portion of the rectum through its continuity and fascial relations with the anal canal receives firm fixed supports, including the visceral fascial collar reflected from the pelvic diaphragm, the levator muscular sling with its caudal fascial ex-

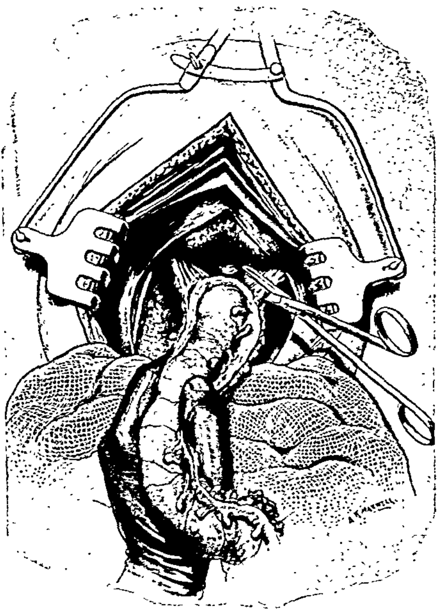


FIG. 85. The lateral ligaments of the rectum. The drawing shows the separation of the anterior connections of the rectum as far as the upper border of the prostate, and division of the lateral ligaments. The lateral incisions in the peritoneum have been extended on either side so as to meet in front behind the base of the bladder. The *lateral ligaments* have been defined as far as the upper surface of the levator ani on either side. These ligaments are then completely divided with scissors, the ureter on the left side having been drawn aside. (Miles, W. E.: *Cancer of the Rectum*. Harrison & Sons, Ltd., 1926.)

tensions and finally the anal sphincter. These combined structures anchor the sphincteric portion of the rectum in the pelvic floor.

The Vascular Supply of the Rectum

The arterial supply to the rectum is mainly through the superior and middle hemorrhoidal vessels and to a lesser extent from the inferior hemorrhoidal vessels. Its distribution is significant to the proper conception of hemorrhoidal disease and will therefore be discussed at some length.

The superior hemorrhoidal artery, accompanied by the same vein, runs in the superior hemorrhoidal sheath of the mesorectum. On reaching the rectal wall at about the level of the second sacral segment it divides into right and left main branches which follow along the lateral peritoneal reflections. They continue in the rectal fascia and finally pierce the rectal wall to reach its submucosa. These main branches give off several secondary lateral branches which ramify around the upper rectum and, piercing its musculature, reach the submucosa where there is free anastomosis between their terminal distribution and the corresponding venules (figs. 86 & 87).

The right main branch divides about three inches above the anorectal line into anterior and posterior branches which reach the annulus hemorrhoidalis in the right anterior and right posterior quadrants. The left main branch does not divide but continues to the lateral aspect of the annulus. This distribution of the three main arterial branches is significant to the formation of the three primary internal hemorrhoids, usually found in the right anterior and right posterior, and left lateral positions (fig. 88). Terminal branches from the right posterior branch and the left main branch form secondary internal hemorrhoids.

The venae comites follow the arterial distribution fairly closely and in the terminal rectum their combined arteriovenous anastomotic capillary network, together with inosculations from the inferior plexus and to a slight degree from the middle hemorrhoidal

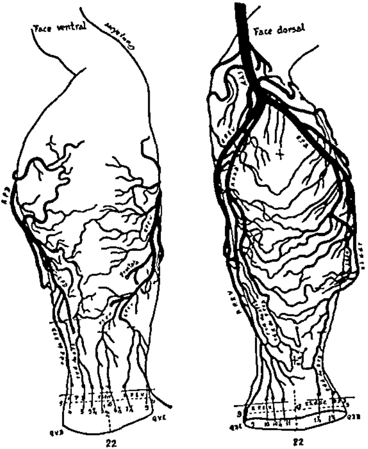


FIG. 86. The superior hemorrhoidal artery and its terminal branches. (After Mammana.)

veins, form the important internal or superior hemorrhoidal plexus.

Owing to this intimacy between terminal arterial and venous radicles, the primary internal hemorrhoids formed in this plexus are fairly constantly related to the terminations of the larger arterial branches. Well developed internal hemorrhoids, usually including the related portion of the external plexus are, therefore, usually situated as previously mentioned.

Mammana also made a commendable detailed study of the

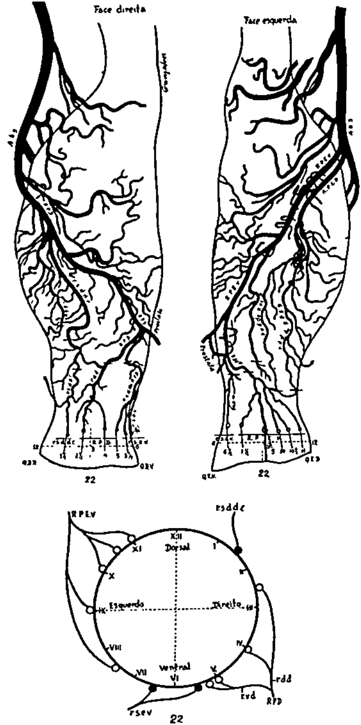


FIG. 87. The terminal distribution of the superior hemorrhoidal artery to the anal quadrants. (After Mammana.)

terminal distribution of the superior and middle hemorrhoidal arteries to the annulus in 50 cases. His findings are confirmative.

He concluded that the terminal distribution primarily from the superior hemorrhoidal artery to the internal hemorrhoidal plexus consisted of primary and secondary branches and that the terminal concentrations of these branches, although quite variable, predominated at 1:30, 5 and 9 o'clock on the annulus, considering the posterior median line as 12 o'clock with the subject in the lithotomy position (fig. 87). Additionally he observed that the annulus received direct branches from the superior hemorrhoidal artery, which he termed a long rectosigmoidal branch.

This study is significant to the surgery, injection treatment and etiology of internal hemorrhoids.

The middle hemorrhoidal, quite variable in its origin size and distribution, usually arises from the anterior branch of the hypogastric artery. It extends in the so-called lateral or triangular ligament of the rectum accompanied by the vein and nerve of the same name and is distributed mainly to the rectal musculature. Its terminal branches anastomose with those of the inferior and superior hemorrhoidal vessels.

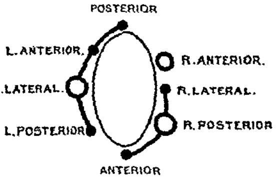


FIG. 88. Arterial distribution to the anal canal. (After Abel.) The diagram shows the position of arteries in the anal canal. These, together with their venae comites, form internal piles, as follows: those indicated by large circles (the main vessels) form primary piles; those indicated by small circles form secondary piles. The commissure is considered as 12 on the clock. Primary piles are usually found at 2, 4, and 9. Patient in the inverted position. (Abel, A. L.: *Lancet*, 1932.)

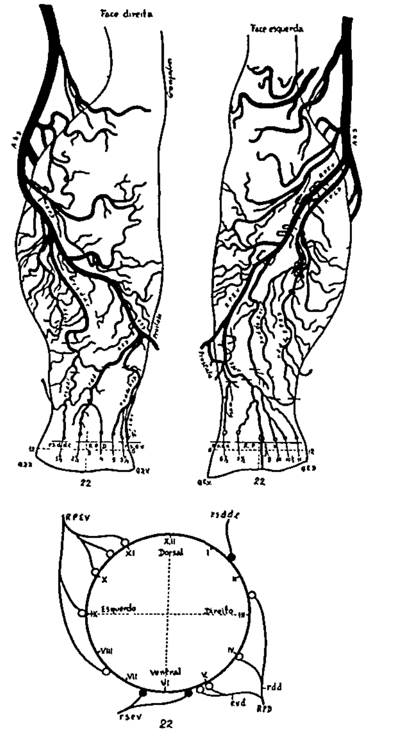


FIG. 87. The terminal distribution of the superior hemorrhoidal artery to the anal quadrants. (After Mammana.)

The lymphatics and nerve supply to the rectum and sigmoid are described in Chapters VIII & IX.

Relations of the Rectum

The anterior relations from the surgical standpoint are the more important. From above downward below the rectovesical peritoneal fold the rectum is in direct relation to the posterior layer of Denonvilliers' fascia covering the seminal vesicles and prostate. Below the prostate it is in intimate relation with the urogenital diaphragm and the prostatic urethra through the mutual attachment of the surgically important rectourethralis muscle. Anterolaterally to the rectum are the medial margins of the levator ani muscles which contribute fibers to the central perineal tendon and course around the anterior aspect of the rectal wall. Above the levator ani muscles the lateral ligaments have important relations to the rectum (see endoplevic fascia, page 228).

In the female the interposition of the vagina and uterus modifies the relations of the rectum. Below the peritoneal pouch it is in relation with the coils of the small gut, the posterior vaginal fornix, and from this point to the perineal junction it is merely separated from the vagina by a stratum of connective tissue—the recto-vaginal septum (fig. 102). This septum corresponds to the comparatively stronger sheet of Denonvilliers' fascia in the male.

Anterolaterally in the female the rectum lies adjacent to the medial legs of the levator ani muscle, the mesenteroids of the vagina, the lateral fascial wings of the vagina, and the lateral ligaments.

Laterally the ureters, the larger branches of the hypogastric artery and the pelvic nerve plexus are the surgically important relations.

Posteriorly below the peritoneal reflection the rectum comes into important anatomic relation with the endópelvic fascia, in both its parietal and visceral portions. Immediately covering its longitudinal coat is a thin but firm reflection of the supra-anal

The inferior hemorrhoidal arteries, although primarily supplying the anal region, also distribute terminal branches to the lower rectum.

The Venous Supply

In general the veins of the rectum follow the corresponding arteries.

The superior hemorrhoidal vein originates in the terminal radicals of the internal hemorrhoidal plexus. These radicals in turn drain into larger veins, usually six or more in number which extend upwards in the submucosa for three or more inches and finally pierce the rectal wall.

These collecting veins have no valves and any back-pressure, which may occur from a variety of intrinsic or extrinsic causes, is readily transmitted to their terminal radicles in the internal hemorrhoidal plexus. This is significant to the etiology of internal hemorrhoids.

After passing through the rectal musculature the collecting veins join the main branches of the superior hemorrhoidal vein, which continues in the mesorectum and mesosigmoid to its termination in the inferior mesenteric vein.

Through its extensive ramification both inside and outside of the rectum and its connection with the portal system, the superior hemorrhoidal venous network is highly significant to the direct and venous metastases of pelvic cancer.

The middle hemorrhoidal vein arises mainly from the terminal radicals which drain the rectal musculature and submucosa of the ampulla. It passes laterally in the so-called lateral ligament of the rectum and terminates in the internal iliac vein. Although the lympatics are of more importance in the lateral spread of cancer, metastases through the vein may rarely account for distant deposits in the lungs or elsewhere as mentioned by Gabriel.

The external hemorrhoidal veins have been discussed in Chapter III.

referred to as the iliac portion) has little or no free mesentery until after it passes from the pelvic brim. From this point it arches across the abdomen in an omega-shaped loop or flexure of various lengths; then, curving downward and backward into the true pelvis, it finally reaches and joins the rectum at a more or less acute angle, approximately at the level of the third sacral vertebra. That portion which occupies the pelvis is referred to as the pelvic colon. The area in conjunction with the rectum is the rectosigmoid, about 8 cm. in length.

The length of the sigmoid flexure and correspondingly the extent of its mesentery and its anatomic relations admit of considerable variation (fig. 89). According to Byron Robinson, the sigmoid may vary in length from 12 to 84 cm. or more. The average length is about 40 cm. in adults and 18 cm. in children.

In contrast to the length of its suspended loop, the line of attachment of the mesentery of the sigmoid to the posterior abdominal wall is considerably less. Extending in an irregular curved manner, the root of the mesentery starts in the upper left iliac fossa, extends downward for a few inches, then mesially, then upward to about the level of the fourth lumbar vertebra, and finally downward again into the true pelvis where it becomes the mesorectum.

Where the sigmoidal mesentery crosses the abdominal wall near the midline posteriorly, it forms a funicular pocket or sac which is twisted around the vascular pedicle. This, like the duodenal fossa, is referred to as the sigmoidal fossa or notch. It is a guide to the vascular stalk (fig. 90).

It may be observed here that the narrower sigmoid joins the rectum as often from the right side as it does from the left, and this, together with the normal twist resulting from the change in direction of its mesenteric attachment, presents an important consideration in the endoscopic examination of this organ. On the basis of these anatomic variations, the author has adopted a proctosigmoidoscopic technic to be referred to presently.

In infants the sigmoid has a more variable pattern than in adults. Boucart has classified sigmoids into three common types:

fascia continued from the upper surface of the levator ani muscle, forming the fascial collar (fascia recti) and fusing at the rectosigmoidal junction with the peritoneum (fig. 125, p. 245).

Directly applied to the fascial collar or fascia recti is the presacral wing of the hypogastric sheath (Uhlenhuth), the so-called "fascia propria" or meso of the rectum, which is a continuation caudally of the superior hemorrhoidal sheath containing the hemorrhoidal vessels, lymphatics and nerves. This presacral fascial wing lies directly on the parietal pelvic fascia overlying the sacrum, the piriformis and coccygeus muscles.

The origin of the presacral wing from the medial margin of the hypogastric sheath forms the lateral strong boundary of the retrorectal space. The important pelvic ganglion is sandwiched in between the two layers of the presacral wing.

Extending from the fascia propria to the parietal pelvic fascia, covering the sacrum and coccyx and traversing the retrorectal space to reach the rectal fascia, are the so-called rectal stalks or shelves (Uhlenhuth) which are sometimes substantial strands of fascia conveying vessels and parasympathetic nerves to the rectum and pelvic ganglion.

Caudally the rectum is surrounded by the puborectalis sling—anorectal muscle ring—and it rests on the supra-anal fascia covering the levator plate.

The Sigmoid

The sigmoid, or sigmoid flexure, is that portion of the large intestine extending approximately from the upper border of the left psoas muscle to the proximal end of the rectum. It is of particular proctologic interest because: 1) it is partially accessible to endoscopic examination; 2) it is a relatively common site for malignant invasion; 3) it is frequently secondarily involved in diseases of the adjacent viscera; 4) it is often the site selected for colostomy.

Like the descending colon, the first part of the sigmoid (also

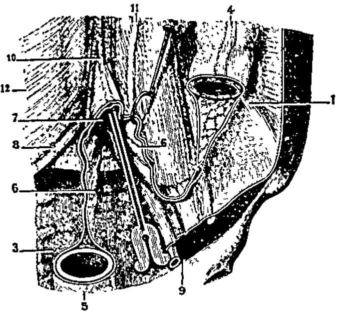


FIG. 90 Parietal insertion of the mesosigmoid. 1, iliac crest; 2, 5th lumbar vertebra; 3, *3rd sacral vertebra*; 4, *descending colon divided at lower end*; 5, rectum; 6, mesosigmoid; 7, intersigmoid fossa; 8, common iliac vessels; 9, external iliac vessels; 10, sigmoid artery; 11, left ureter; 12, lower (or left) leaflet of mesentery (Testut. *Anatomie topographique*. Doin, 1905.)

the ascending, 75 to 80 per cent; the transverse, 20 to 25 per cent; and the descending, rare. These variations are significant to endoscopic examination.

The Mucosa and Submucosa

These are essentially the same as in the remainder of the large intestine. The rectal mucosa is somewhat more richly vascularized, is slightly thicker (particularly in the region of the annulus), and contains a larger number of goblet cells and solitary follicles.

The submucosa of the sigmoid is practically the same as the remainder of the large gut. In the rectum it has a peculiar disposition in the valves and in the annulus hemorrhoidalis. So-called mucous membrane prolapse is rather common to the rectum but not to the sigmoid.

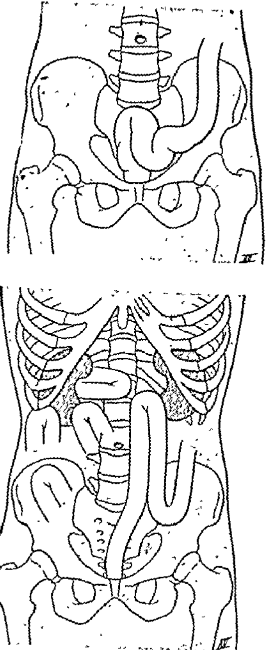


FIG. 89 Above: the normal sigmoid Below: abnormal lengths and varying positions of the sigmoid flexure. (Bensaude: *Rectoscopie*, Ed. 2. Masson et Cie., 1926.)

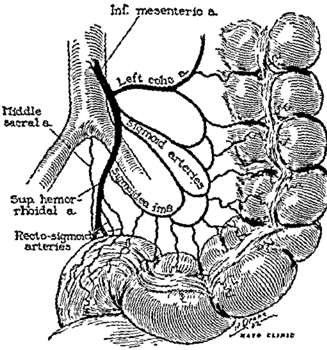


FIG. 91. Blood supply of the sigmoid and rectosigmoid. (Rankin, F. W., Bargen, J. A., and Buie, L. A.: *The Colon, Rectum, and Anus.* W. B. Saunders, 1932.)

served. These observations are important in the broadening scope of cancer surgery.

The arterial anastomotic looops of the sigmoid are somewhat variable and Pope has described them as conforming more or less to five different orders or patterns. The length of the mesentery appears to have but little influence on their arrangement.

It may be noted at this point that the arterial supply to the sigmoid should be distinguished from that of the rectosigmoid, which has definite anatomic boundaries. Because of its variations in position and direction, and because of the peculiar disposition of its peritoneal coat, the rectosigmoid has acquired a special surgical significance and terminology. It is approximately 8 cm. in length and corresponds in position roughly to the third sacral vertebral body. The normal physiologic excursions of the sigmoid into the rectum, however, vary its position.

The Muscular Layers

These consist of an inner circular and outer longitudinal tunic which follow the general arrangement of the colonic musculature. At *the rectosigmoidal junction, however, the inner circular coat* becomes more prominent and forms the questionable third sphincter of O'Beirne. The longitudinal muscular bands—the taenia coli—of the sigmoid spread out to continue over the rectum as its *outer musculofascial sheath.*

The appendices epiploicae of the sigmoid gradually reduce in size and number as the rectum is reached.

The Blood Supply

The sigmoid receives its blood supply primarily through the inferior mesenteric artery and its anastomotic branches. Arising from the anterior aspect of the aorta about 2 cm. above its bifurcation, this vessel extends subperitoneally on *the left side and gives* off the left colic and sigmoidal branches which ramify and anastomose in the mesosigmoid. Below the sacral promontory it becomes the superior hemorrhoidal. Sigmoidal branches may also arise from the superior hemorrhoidal as well as from *the left colic* branch.

The sigmoidal branches vary widely in number (one to seven), in size and in their anastomotic distribution. The anastomotic arrangement along the mesenteric border of the gut, which is common to the entire colon, preserves the continuity of the marginal artery. However, in the sigmoid this artery is located somewhat farther from the edge of the gut than in the colon and small intestine, *a point of surgical importance in anastomoses and* resection of the sigmoid (fig. 91).

The blood supply through the marginal artery to the colon and sigmoid, according to Ault and others appears, to be adequate *after ligation of the inferior messenteric at its aortic origin* or of the superior hemorrhoidal artery and its anastomotic loops. Consideration of the critical point of Sudeck which is somewhat variable is hence no longer necessary. Anomalies are rarely ob-

bridge, the possibilities of subsequent closure, and the lack of tension on the mesentery are advantages more often presented by the transverse colon which is now the site usually selected for colostomy.

Endoscopic Considerations

The writer has come to the conclusion that the sigmoidoscopic examination may be greatly simplified and carried out with greater satisfaction and with practically no risk of perforation by what we have termed a "two-scope" technic, in which the sigmoidoscopic examination is based on the information gained by a careful proctoscopy. Appropriate-sized tubes are used for each procedure. The proctoscopy should be done with a 7-inch tube of 1-inch diameter. Sigmoidoscopy should be carried out with a tube of appropriate size, as the case indicates.

A properly illuminated short tube not only gives an unexcelled view of the entire rectum and frequently suffices for the diagnosis (with biopsy or smear), but also reveals to the proctoscopist the exact site of the rectosigmoidal junction. It also discloses the usual curving axis of the sigmoid, which is *the most important single factor* in the passage of a scope of any size through the normal or abnormal sigmoid. The usually more or less angulated or introverted rectosigmoidal junction or fold which is commonly confounded with the third rectal valve is the stumbling block for most proctoscopists. It is not sufficiently appreciated that the sigmoid may, with a single or double turn, extend from the rectal junction at almost any angle.

Furthermore the sigmoidal loops may be more or less fixed by pathologic adhesions from the adnexa, by abnormal position, by a short mesentery or by other intrarectal, extrarectal or sigmoidal pathology. It should be most carefully noted that the sigmoid, if mobile, actually unrolls itself and sometimes untwists itself over the end of the sigmoidoscope, and that it conforms, as far as possible, with the straight axis of the instrument as it is lifted out of the pelvis.

The small arteries distributed to the rectosigmoid from the superior hemorrhoidal are, according to Pope, fairly constant, and this portion of the intestine might be delineated on the basis of its arterial supply.

The rectosigmoid is supplied by one or more branches which arise from the superior hemorrhoidal. The first branch is situated about 2 cm. below the sacral promontory and after anastomosing with the last sigmoidal branch it continues in the mesorectum to supply the posterior aspect of the sigmoidal junction and the upper rectum, anastomosing with the remaining branches from the superior hemorrhoidal.

The superior hemorrhoidal artery continues medially, and commonly bifurcates or trifurcates at the level of the third sacral vertebra into lateral branches which are distributed as already described under the Rectum (see p. 166).

The venae comites are distributed in close conformity with the arteries and require no further description. They drain into the portal system largely through the inferior mesenteric vein.

The nerve supply is by way of the sympathetic and parasympathetic systems (see p. 285).

Surgical Considerations

The length of the mesosigmoid is of some importance in the selection of a colostomy technic. In our experience an unpredictable amount of retraction of the colostomy stomata may follow when the mesosigmoid is too short or is unduly stretched in keeping a satisfactory loop of gut above the skin surface. Persistent postoperative pain may also be a troublesome sequel. Incisions into the retroperitoneal tissues to mobilize the sigmoid are attended by an increased mortality. In sigmoidal colostomies established in cases of rectal stricture (lymphopathia venereum,) the sigmoid may eventually become involved in the process and it has been necessary on several occasions for the writer to use the transverse colon secondarily.

The ease of separation of the colostomy stomata by a large skin

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In the diseased bowel the mobility is more or less restricted, and efforts directed contrary to the axis of the bowel place considerable tension and stress on the gut wall itself, on its mesentery or on whatever else may limit its excursions. These misdirected manipulations are often provocative of reflex muscular spasm—painful stimuli which provoke abdominal straining, increasing the possibilities of undesirable trauma.

The great importance, therefore, of determining if possible the axis of the sigmoidal loop, its mobility, or pathologic fixation and, finally, of advancing the sigmoidoscope with these factors in mind cannot be overemphasized.

In this connection, the informative value of modern roentgenographic studies in the oblique positions and of the double air contrast enema with fluoroscopy should be kept in mind.

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CHAPTER VI

The Perineopelvic Spaces

General Considerations

The spaces, potential or actual, of the perineum and pelvis are anatomic sites which are of practical importance not only for an adequate clinical concept of the pathogenesis and extensions of infectious and malignant processes of the pelvis and perineum but also for an adequate surgical management of these conditions. Furthermore, the perineal spaces with their contained structures are directly concerned in the modern surgical therapy of hemorrhoids, fissure and fistula. The descriptions here given will emphasize the surgical and practical viewpoint rather than the strictly anatomic which in some cases is still controversial. In several instances the spaces are merely planes of cleavage between more or less closely opposed fascial capsules of adjacent organs, e.g. the prerectal, posterior prostatic, retrorectal or rectovaginal spaces. The pathologic invasion of the spaces, largely by infectious processes, has led to an anatomic pattern for surgical convenience and approach. This is particularly true of the spaces surrounding the rectum and prostate. The boundaries of the spaces are usually described in terms of fascia, which varies widely in smooth muscle content, density and particularly tensile strength. The pelvic fascia, therefore requires histologic evaluation in connection with the surgical anatomy of the spaces.

On the basis of the levator ani muscle the perineopelvic spaces may be conveniently classified into an infralevator and supralevator group. It is suggested that this muscle be reviewed in conjunction with the spaces.

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anal canal (p. 33). Therefore, if one considers the anorectal muscle ring as the upper limit of the anal canal the submucous space would occupy the upper third of the anal canal. If the anorectal line is considered the upper limit of the anal canal the submucous space would occupy the terminal rectum.

The submucous space contains the internal hemorrhoidal plexus of veins arising from a terminal arteriovenous anastomotic network; a supporting fibro-elastic connective tissue matrix; an extensive lymphatic plexus particularly prominent in the columns of Morgagni, and a well developed muscularis mucosae—the sustentator tunicae mucosae of Kohlrausch. A continuation of this muscularis into the pecten of the anal canal joins the terminal extensions of the conjoined longitudinal muscle to form the "Musculus Submucosae Ani" (Fine and Lawes) (p. 79).

Internal hemorrhoids and anal prolapse result from hypertrophy, dilatation and attenuation of the various tissues in the submucous space. Hemorrhoidal disease may well be considered as a composite pathological process partly of vascular and partly of fibrillolytic origin, in which infection probably plays a significant role.

These anatomicopathologic considerations are pertinent to the proper treatment of internal hemorrhoids, particularly the injection form of therapy, and in the common condition of pectenosis or anal fibrosis.

The Perianal Space

This space was originally considered the small sulcus surrounding the subcutaneous external sphincter muscle. Milligan has recently described it as extending much further laterally and posteriorly and corresponding in general to the boundaries of the anal triangles. This space is demarcated from the ischiorectal space above it by the lateral extensions of the conjoined longitudinal muscle—the transverse septum of the ischiorectal fossa (fig. 92). This septum extends from the anal intermuscular septum to the lateral limits of the anal triangles. It marks an abrupt

The Infralevator Spaces

The submucous space
The perianal space
The ischiorectal (ischioanal) space
The postanal spaces:
  superficial postanal space
  deep postanal space
The perineal compartments (pouches):
  the superficial perineal compartment
  the deep perineal compartment (triangular ligament, urogenital diaphragm).

The Submucous Space

The exact anatomic description of this space depends on the particular concept held concerning the limits of the anal canal (p. 33). Directly above the anorectal line the internal hemorrhoidal plexus occupies the submucous space which extends upward to the level of the anorectal muscle ring (fig. 92). This ring is sometimes considered and described as the upper level of the

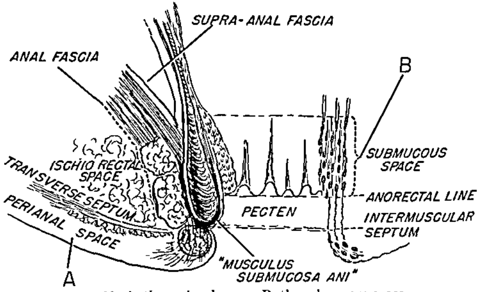


Fig. 92. A, the perianal space; B, the submucous space.

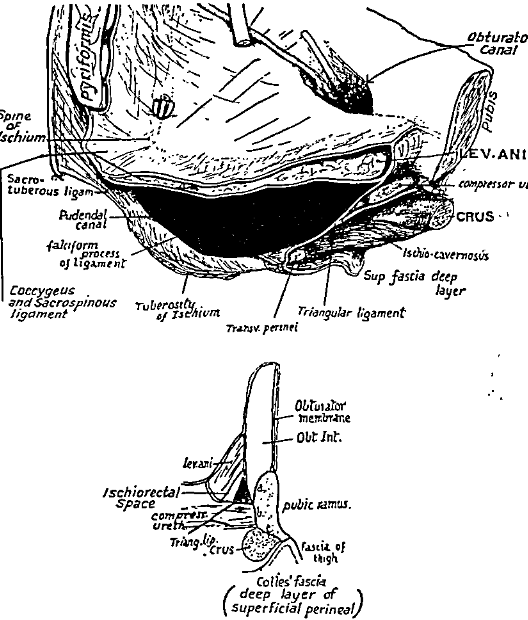


FIG. 93. Above: Scheme of a section through the front part of the ischiopubic ramus *a*, surface for origin of obturator internus; *b*, surface for compressor urethrae; *c*, everted surface for crus. The apex of the anterior extension is well shown in red. (After Frazer.) Below: Pelvis seen from below; left side, showing in diagrammatic form the structures in position. (Ischiorectal space in red.) (After Frazer.)

change in the density and direction of the superficial perineal fascia which further accentuate it as a limiting membrane. The perineal fascia and fat of the perianal space is rather closely woven and compact in comparison to the loose fatty matrix of the ischiorectal space.

The anal boundary of the perianal space is the sensitive anoderm of the lower third of the anal canal, its anterior limit is the posterior border of the superficial transverse perineal muscle. The posterior portion of this space behind the anal canal has received the surgically convenient designation of the superficial post-anal space (posterior triangular space, space of Brick, etc.).

The contents of the perianal space include the subcutaneous external anal sphincter muscle, the terminal extensions of the conjoined longitudinal muscle (corrugator cutis ani muscle), the external hemorrhoidal veins, the superficial perianal lymphatics and a controversial nerve plexus (the plexus analis).

Clinically the involvement of this space and its related structures in the more common and usually painful minor anorectal conditions warrants its recognition as a separate anatomical space as described by Milligan.

Not to be confused with this space is the so called "circumanal space." Courtney by this term refers to a circumanal hiatus between the inferior margin of the internal sphincter muscle and "those fibers from the combined longitudinal muscle layer (conjoined longitudinal muscle) which form the anal intermuscular septum and insert into the skin of the anal canal" (see p. 78).

The Ischiorectal Space

The ischiorectal space and the perianal space are subdivisions of the ischiorectal *fossa*.

The ischiorectal space is the most important of the infralevator spaces. It corresponds topographically to the boundaries of the anal triangles with anterior extensions (Waldeyer) overlying the urogenital diaphragm and less important posterior recesses above the lower border of the gluteus maximus muscles (fig. 93).

tinuous with the actual roof of the space which is formed by the caudally and transversely directed iliococcygeus muscle. Posteriorly the roof becomes continuous with the base (not the floor) which is formed by the sacro-spinous ligament partly overlapped by the gluteus maximus muscle.

The floor of the ischiorectal space behind the urogenital diaphragm is the transverse septum or roof of the perianal space.

The entire ischiorectal space is lined by the infra-anal fascia and it contains a pad of large fat globules interlaced in a thin collagenous matrix.

Traversing each space from its postero-lateral angle is the vascular pedicle containing the inferior hemorrhoidal artery, veins and nerve which supply the anal musculature, the anal canal and the perianal skin. The arrangement of the vessels and nerves in relation to the anal musculature is significant to the technique of local infiltration anesthesia and the injection of the oil-soluble anesthetic anucaine.

Traversing the space anteriorly behind the triangular ligament is a thin vascular sheath which contains the anterior sphincterian vessels and nerves to the anterior aspect of the anal sphincter and the perineal skin. This sheath is not to be confused with the transverse perineal artery and nerves.

The fourth sacral nerve crosses the lower border of the gluteus maximus muscle about 2 cm. from the coccyx and traverses the posteromedial portion of the space. The posterior perforating branches of the second and third sacral nerves also leave the space below the gluteus maximus muscle about midway between coccyx and ischial tuberosity.

In the male the ischiorectal spaces are smaller, narrower and somewhat deeper. In the female, due to the interposition of the vagina, the anterior boundaries and extensions are less well defined.

Average measurements of the spaces are 6 to 8 cm. antero-posteriorly, 2 to 4 cm. in width and 6 to 8 cm. in depth. Further details of the blood and nerve supply may be found in Chapter III.

This space is irregularly wedge-shaped anteroposteriorly, with its apex at the pubic angle and its base at the gluteus maximus muscle. *Owing to the sacral curve the coccyx, ischial spine and* the pubes all lie on approximately the same horizontal level and the roof of this space is therefore actually horizontal rather than peaked, as it is commonly described. It presents inner and outer walls, a roof, base and floor (fig. 93).

The inner wall is formed by the superficialis and profundus portions of the anal sphincter muscle and the superimposed puborectalis and pubococcygeus muscles. *The pubic origin of the* levator ani muscle from the urogenital diaphragm also forms the inner wall of the anterior extensions (fossa of Waldeyer). At the apex of this fossa the inner wall meets the outer wall which is formed by the fascia lunata (Derry) reflected from the obturator fascia (fig. 93).

Posteriorly the inner walls of the right and left ischiorectal spaces are continuous and there is rather free communication between them by way of the deep postanal or posterior communicating space, "*posterior subsphincteric space*" (Courtney). This space is directly below the levator plate and it is the usual level *of the communicating tract in the posterior horseshoe fistula.* Below the deep postanal space the ischiorectal spaces are separated by the anococcygeal ligament and the subcutaneous tissues of the perianal space.

The ischiorectal spaces in the male also communicate anteriorly above the superficialis portions of the external anal sphincter muscle through an anterior communicating space. This space is poorly defined *in the female on account of the perineal body.* Anterior horseshoe fistulas are comparatively uncommon in both sexes.

The roof of the ischiorectal space is commonly considered as the *cleft formed by the junction of the pubococcygeus* muscle with the obturator fascia at the "white line" of the levator ani muscle. The *pubococcygeus and iliococcygeus muscles join,* as emphasized by C. N. Morgan, and become continuous posterior to the obturator foramen *and the so-called cleft becomes con-*

noted, is the posterior portion of the *perianal* space. It extends posteriorly from the anal verge into the subcutaneous tissues between the superficialis portion of the external anal sphincter muscle and its extensions to the *dorsum* of the coccyx. The deepest portion of this space is that directly dorsal to the annular fibers of the subcutaneous external anal sphincter muscle as they bridge the diverging legs of the superficialis portion of this muscle—the recess commonly referred to as the "weakest point" of the anal circumference (which is scarcely true). The indefinite lateral boundary of this space is formed by the fibro-elastic extensions of the conjoined longitudinal muscle (the corrugator cutis ani fibers). These terminal extensions insert into the skin and fascia covering the posterior legs of the superficialis portion of the external anal sphincter muscle. This arrangement tends to confine postanal infections to the superficial tissues of the posterior midline, as commonly observed in abscess and sinus formation complicating anal fissures, etc.

The contents of this space are essentially the same as previously described for the perianal space. It also contains the terminal nerve filaments of the anastomotic loops of the posterior division of the sacral nerves. This may perhaps account for the extreme pain in chronic anal fissure.

THE DEEP POSTANAL SPACE (posterior communicating space; subsphincteric space, Courtney). The deep postanal space is the deeper recess located above the superficialis portion of the external sphincter muscle, posterior to the puborectalis muscle and deep portion of the anal sphincter, and below the levator plate. It extends posteriorly in this interval to the tip of the coccyx. It contains loose fatty areolar tissue. Since the adjacent ischiorectal spaces communicate freely through this recess it is called the posterior communicating space (fig. 95). The anal or infra-anal fascia coursing on the inferior surface of the levator ani muscles lines and is continuous through this space.

Anatomical differentiation of the above-described spaces may perhaps appear somewhat academic. The postanal tissues may be

The Postanal Spaces

There are two spaces dorsal to the anal canal which are significant to the common postanal infections and their extensions. These are conveniently termed the superficial and deep postanal spaces (fig. 94).

THE SUPERFICIAL POSTANAL SPACE. This space, as previously

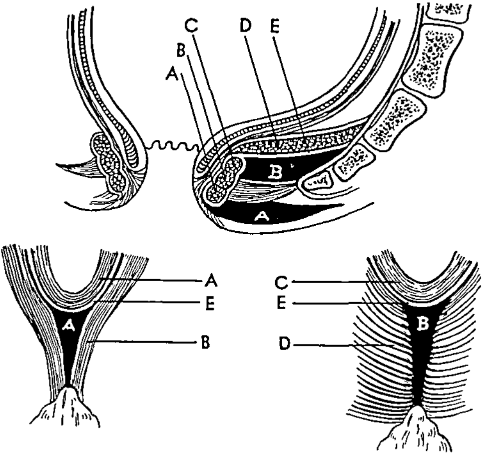


FIG. 94. The superficial postanal space (posterior triangular space); the deep postanal space. A, the subcutaneous external sphincter; B, superficialis external sphincter; C, profundus external sphincter; D, levator plate; E, anal or infra-anal fascia which, together with the levator plate, forms the roof of the deep space. In the horseshoe type of posterior fistula, the communication from one ischiorectal fossa to the other is directly through the deep space.

noted, is the posterior portion of the *perianal* space. It extends posteriorly from the anal verge into the subcutaneous tissues between the superficialis portion of the external anal sphincter muscle and its extensions to the *dorsum* of the coccyx. The deepest portion of this space is that directly dorsal to the annular fibers of the subcutaneous external anal sphincter muscle as they bridge the diverging legs of the superficialis portion of this muscle—the recess commonly referred to as the "weakest point" of the anal circumference (which is scarcely true). The indefinite lateral boundary of this space is formed by the fibro-elastic extensions of the conjoined longitudinal muscle (the corrugator cutis ani fibers). These terminal extensions insert into the skin and fascia covering the posterior legs of the superficialis portion of the external anal sphincter muscle. This arrangement tends to confine postanal infections to the superficial tissues of the posterior midline, as commonly observed in abscess and sinus formation complicating anal fissures, etc.

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Anatomical differentiation of the above-described spaces may perhaps appear somewhat academic. The postanal tissues may be



FIG. 95 The deep postanal space. The probe passes above the superficialis external anal sphincter muscle through the deep postanal space (posterior communicating space).

invaded by infectious processes which burrow posteriorly at any level. However it is repeatedly observed clinically that superficial infections which arise from below the subcutaneous external anal sphincter muscle usually extend posteriorly in the superficial postanal space or laterally in the perianal space. On the other hand, extensions from the anal canal or coccyx to the deep postanal space are prone to invade the adjacent ischiorectal spaces. It is commonly through the deep postanal space that adjacent ischiorectal spaces become infected, terminating in the common horseshoe variety of anal fistula.

Courtney refers to the deep postanal space or posterior communicating space as the "posterior subsphincteric space" and he describes it as a "tract posterior to the anus and between two prolongations of the puborectalis muscle." We have been unable to confirm "two prolongations of the puborectalis muscle" between which this space is found. In our dissections this space lies posterior to the anal canal, not the anus, between the superficialis external anal sphincter and the levator plate. It is sub-levator rather than subsphincteric and it is the usual level of communication between adjacent ischiorectal spaces.

It may be noted here that the anatomical arrangement of the superficialis portion of the external anal sphincter muscle forms an anterior communicating space in the male but not in the female. The incidence of deep infections anterior to the rectum is comparatively much less than posteriorly and an anterior communicating space in either sex is not generally recognized.

The Perineal Compartments (Pouches)

These compartments, superficial and deep, are sometimes considered as perineal spaces. They are mentioned for the sake of completeness. They are described in Chapter I.

THE SUPRALEVATOR SPACES

General Considerations

The peritoneum reflected over and between the pelvic viscera forms the roof of the large sub-peritoneal area commonly referred to as the supralevator space (deep pelvic, pelvorectal, etc.). The floor of this space is the pelvic diaphragm covered by the supra-anal fascia (supralevator, levator, superior layer of the pelvic diaphragmatic fascia, etc.). Its peripheral boundaries are roughly the symphysis pubes anteriorly, the obturator muscle and its fascia laterally and the piriformis muscle and sacrum posteriorly.

This large area contains the irregular and complex ramifications of the visceral endopelvic fascia.

Clinically, in referring particularly to abscesses, any infectious process not definitely diagnosed as situated below the levator ani muscle is usually loosely referred to as supralevator, etc. This extensive supralevator space in both sexes is divided into two well defined and surgically important compartments. In the female the rectovaginal septum and its lateral extension separate an anterior or vesicovaginal or urogenital compartment from a posterior or rectal compartment (fig. 96); in the male the rectogenital septum separates an anterior vesicoprostatic or urogenital compartment from a posterior or rectal compartment (fig. 97).

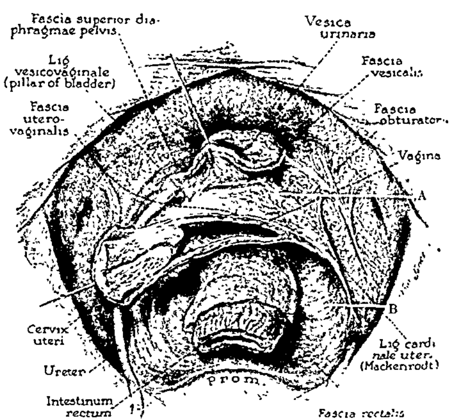


FIG. 96. The anterior and posterior compartments of the supralevator space (female). (Modified from Curtis.) A, anterior compartment; B, posterior compartment.

These secondary compartments are further divisible into smaller actual or potential spaces by fascial sheaths or wings extending from the fascial collars of the several viscera to attachments on the pelvic wall or to the fascia endopelvina in the pelvic diaphragm. Reflected from the viscera at different levels, these fascial wings form a framework for the pelvic vascular, lymphatic and nerve supply. They additionally provide some visceral support.

The anterior or urogenital compartment in the female includes the following spaces: the prevesical space (Retzius); and the retrovesical space, divided by the vagina into ventral vesicocervi-

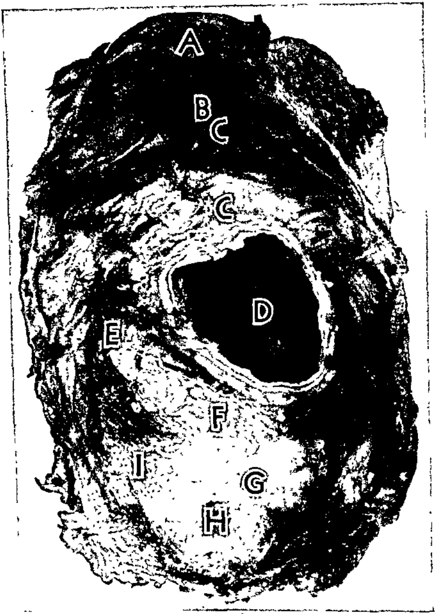


Fig. 97. The anterior and posterior compartments of the supra-levator space in the male. Dissection by the author. The rectum and prostate transected at the level of the seminal vesicle (diseased on the right side). Note how the levator ani muscle "hammocks" the rectum and prostate gland. The retrorectal and supra-levator spaces are well shown. A, end of sacrum; B, parietal pelvic fascia; C, retro-rectal space; D, rectum; E, posterior compartment supra-levator space; F, seminal vesicle; G, prostate; H, urethra; I, anterior compartment supra-levator space.

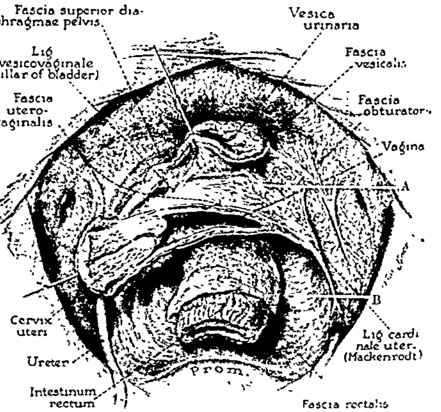


FIG. 96. The anterior and posterior compartments of the supralevator space (female). (Modified from Curtis) A, anterior compartment; B, posterior compartment.

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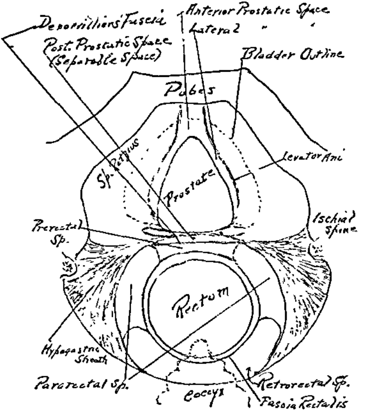


FIG. 99. The supra-levator spaces (male). Schematic.

minor important subdivisions has been confounded by the constantly changing terminology and descriptions of the pelvic fascia.

Anterior Compartment of the Supralevator Space (Female)

The prevesical space
The retrovesical space:
  Vesicocervical space
  Vesicovaginal space
The retrovaginal and prerectal spaces.

THE PREVESICAL SPACE (Retzius). This potentially large space, partially surrounding the urinary bladder, may be described as consisting of two anteromedian recesses and two lateral compart-

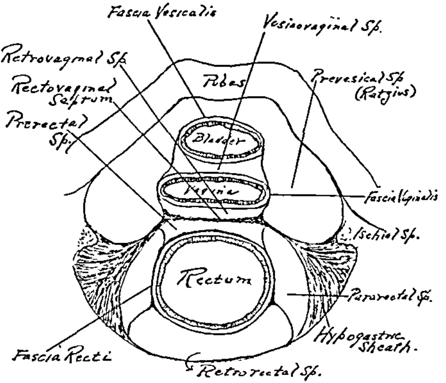


FIG. 98. The supra-levator spaces (female). Schematic.

cal and vesicovaginal spaces and dorsal retrovaginal and prerectal spaces (fig. 98).

The anterior compartment in the male includes the following spaces: the prevesical space (Retzius); the rectovesical space, divided by the rectogenital septum into ventral retrovesical and retroprostatic spaces; and a dorsal prerectal space. Anterior and lateral periprostatic spaces are minor subdivisions of this compartment in the male. These have been described by the urologists for more accurate localization of periprostatic abscesses (fig. 99).

The posterior supralevator compartment in both sexes may be divided into pararectal and retrorectal (presacral) spaces. The latter is supralevator but not entirely subperitoneal. It is potentially the largest of the supralevator spaces (figs. 98 and 99).

The surgical anatomy of the supralevator spaces as well as their

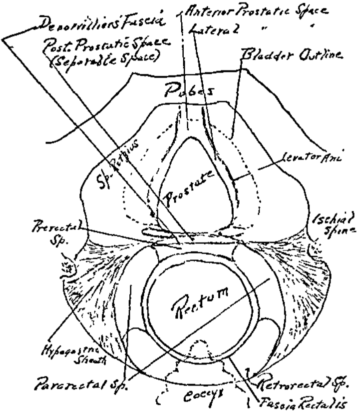


FIG 99. The supra-levator spaces (male). Schematic.

minor important subdivisions has been confounded by the constantly changing terminology and descriptions of the pelvic fascia.

Anterior Compartment of the Supralevator Space (Female)

The prevesical space
The retrovesical space:
 Vesicocervical space
 Vesicovaginal space
The retrovaginal and prerectal spaces.

THE PREVESICAL SPACE (Retzius). This potentially large space, partially surrounding the urinary bladder, may be described as consisting of two anteromedian recesses and two lateral compart-

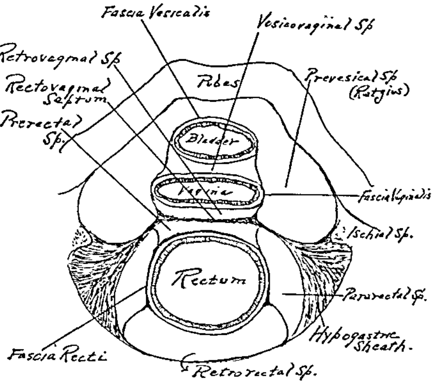


FIG. 98. The supra-levator spaces (female). Schematic.

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The surgical anatomy of the supralevator spaces as well as their

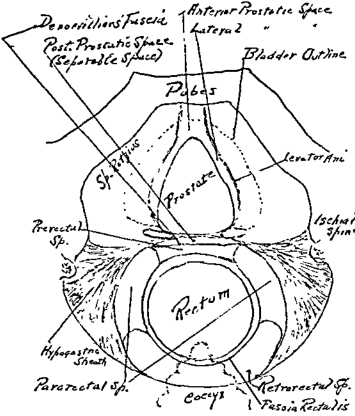


FIG. 99. The supra-levator spaces (male). Schematic.

minor important subdivisions has been confounded by the constantly changing terminology and descriptions of the pelvic fascia.

Anterior Compartment of the Supralevator Space (Female)

The prevesical space
The retrovesical space:
  Vesicocervical space
  Vesicovaginal space
The retrovaginal and prerectal spaces.

THE PREVESICAL SPACE (Retzius). This potentially large space, partially surrounding the urinary bladder, may be described as consisting of two anteromedian recesses and two lateral compart-

ments. The upper median recess lies behind the anterior abdominal wall roughly between the inferior hypogastric arteries and extends upward toward the umbilicus. The lower recess lies directly behind the pubes and contains a wedge-shaped mass of fat—the retropubic fat pad. The floor of this lower recess is formed by the pubourethral ligaments in the female, and the medial pubo-prostatic ligaments in the male—true ligaments of the bladder; its roof is the floor of the larger anterior recess through which the lateral *compartments communicate. The roof of the anterior recess is* the peritoneal reflection from the dome of the bladder to the abdominal wall, supported by the median umbilical ligaments *(urachus). Like the retrorectal space this anterior recess is potentially* expansive and capable of accomodating large extravasations. Its peritoneal relations vary with the degree of distention of the urinary bladder.

The lateral compartments of the space of Retzius have been described by Uhlenhuth as consisting of lateral and median walls, a roof, a floor, and a dorsal wall. The lateral wall is formed partly by the parietal fascia overlying the obturator muscle and partly by the supra-anal fascia. The median wall is the bladder capsule and the inferior hypogastric sheath which separates this space from the vesicovaginal space. The median wall is of surgical importance inasmuch as the inferior hypogastric wing contains the ureter and the main neurovascular supply to the bladder and prostate.

The floor of the lateral compartment is formed by the fascia endopelvina which affords attachment for the true lateral and medial ligaments of the bladder. The dorsal wall of this compartment is the root of the hypogastric sheath and the ischial spine.

The roof of the lateral compartment is formed by the hypogastric fascia (the superior hypogastric wing), covered by peritoneum reflected to the lateral pelvic wall.

THE RETROVESICAL SPACE. This space in the female is divided by the cervix and vagina into two anterior spaces, the vesicocervical and vesicovaginal spaces, and a posterior retrovaginal space.

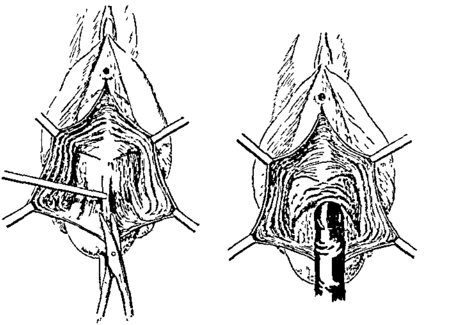


FIG. 100. Left: division of the vesicocervical ligament. Right: after the vesicocervical space has been exposed the bladder is mobilized upward. The bladder septa must first be cut through. (After Shaw.)

The former spaces may conveniently be described together. They are separated by a fascial septum—the supravaginal septum (supragenital in the male) which forms the roof of the vesicovaginal space and the floor of the vesicocervical space. The supravaginal septum is sometimes called the vesicocervical ligament (fig. 100). Cranially the vesicocervical space is bounded by the uterovesical peritoneal fold and laterally by the fascia above the uterovesical ligaments.

The vesicovaginal space extends caudally from the supravaginal septum, its roof, to the urethrovaginal junction above the deep layer of the urogenital diaphragm. As noted by Goff there is no fascial cleavage plane between the urethral and vaginal walls above the urogenital diaphragm. The urethra lies in a fused musculofascial sheath similar to the perineal body. In the floor of this space the pubo-urethral (Curtis), posturethral ligaments (Shaw) surround the urethra. Laterally the vesicovaginal space is

bounded by the strong fascial connections between the bladder and cervix—the uterovesical ligaments or "pillars of the bladder" (Curtis) (fig. 101).

The above spaces are of particular significance in the repair of cystocele, urethrocele and hysterectomy.

THE RETROVAGINAL AND PRERECTAL SPACES. Although the prerectal space is not generally considered a subdivision of the retrovesical space, it may conveniently and simply described in conjunction with the retrovaginal space.

The interpretation of these opposed spaces depends on the disposition of the controversial rectovaginal (rectogenital) septum or fascia. There appears to be some disparity between the gynecologic and anatomic concept of this septum, a matter largely of fascial interpretation and terminology. It has been generally accepted and recognized that the fascial envelopes or collars of the adjacent vaginal and rectal walls are separated by a layer of fibro-areolar tissue—the rectovaginal septum. According to Goff

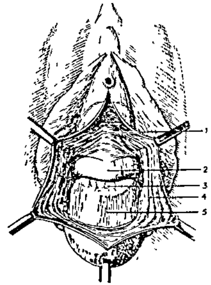


FIG. 101. Exposure obtained after mobilization of the bladder. 1, posturethral ligament; 2, bladder; 3, peritoneum of the uterovesical pouch; 4, vaginal fascia; 5, front of cervix. (After Shaw.)

this cannot be considered as fascia in the surgical sense. Ricci and his co-workers consider the "fascial" terms rectovaginal, vesicovaginal, urethrovaginal and pubocervical as gynecologic misconceptions. They consider the rectovaginal septum as split off from the "fibromusculo-elastic" vaginal wall and hence non-existent. On the other hand, Uhlenhuth describes the septum as readily differentiated and separate from the fascial capsules of the adjacent viscera, in the infant as well as in the adult. The embryology would indeed confirm this view (fig. 102).

Curtis refers to the rectovaginal septum as including the vaginal and rectal capsules with the intervening "cellular tissue."

Anatomists in general recognize a separate rectovaginal septum and also its homologue the rectovesical or rectogenital septum in the male.

The retrovaginal and prerectal spaces have identical boundaries, the former merely separated from the latter by the rectovaginal

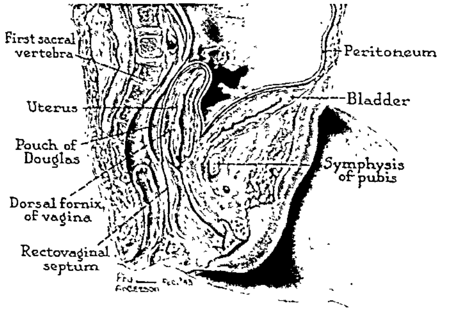


FIG. 102. Left half of pelvis of Negro female infant born at term as it appeared in lateral view, showing the rectovaginal septum. (After Uhlenhuth.)

septum. The upper limits of both spaces are marked by the attachment of the septum to the peritoneal fold in the rectouterine pouch (Douglas).

The inferior recess of the spaces terminates sharply at the line of fusion between posterior vaginal wall and the anal canal at the apex of the perineal body. The lateral walls extend to the fused rectal and vaginal capsules which form the lateral wing of the vagina.

It may be noted in passing that the rectovaginal septum (rectogenital septum in the male) is in more intimate contact with the vaginal (prostatic) wall than the rectal wall. This is significant to proctologic, urologic and gynecologic surgery. Separation of the vagina is more readily accomplished if the natural cleavage plane is entered above the inseparable perineovaginal fusion (perineal body).

Anterior Compartment of the Supralevator Space (Male)

- Prevesical space (Retzius)
- Rectovesical Space:
  - Retrovesical space
  - Retroprostatic space (Proust)
  - Prerectal space
- Periprostatic spaces:
  - Lateral
  - Anterior

THE PREVESICAL SPACE (Retzius). This space is essentially the same as described for the female (p. 197). The pubic approach to prostatectomy has recently enhanced its surgical importance.

THE RECTOVESICAL SPACE. This space is divisible into three surgically important spaces between the bladder, rectum and prostate—the retrovesical, posterior prostatic and prerectal spaces.

The Retrovesical Space. This space is bounded ventrally by the bladder, dorsally by the rectogenital septum and caudally by the attachment of this septum to the posterior lobe of the pros-



FIG. 103 A, rectum; B, peritoneal sac; C, retrovesical space; D, cord; E, visceral fascia; F, bladder. The handle of the probe is in the urethra, the bent probe is in the left ureter and the match stick in the rectovesical peritoneal pouch. The pouch is more firmly attached to the base of the bladder than to the rectum. Note the beginning of the retrovesical space just below and ventral to the peritoneal fold.

tate (fig. 103). Caudal to this attachment and between the two layers of the rectogenital septum is the retroprostatic space of Proust. The roof of the retrovesical space is formed by the rectovesical peritoneal fold which becomes continuous with the supragenital fascia directly behind the bladder. This fascia must be divided before the retrovesical space can be entered. A thin but

substantial layer of fascia—the genital fascia originating from the supragenital fascia—is continued caudally in this space to form a sheath for the seminal vesicles and the ampulla of the vas. Laterally the retrovesical space is bounded by the inferior hypogastric wing which contains the ureter, and neurovascular supply to the seminal vesicles, vas and prostate.

The Posterior Prostatic Space (Retroprostatic Space of Proust). This space is the cleavage plane between the layers of the rectogenital septum (Denonvilliers' fascia). It is of importance in the perineal approach to the prostate gland and its adnexa. As already noted, this space lies caudal to the attachment of the rectogenital septum to the cranial margin of the posterior lobe of the prostate (fig. 104).

The Prerectal Space. This space is bounded ventrally throughout its entire extent by the rectogenital septum; dorsally by the rectal fascial collar and cranially by the rectal attachment of the peritoneum in the rectovesical pouch and caudally by the rectourethralis muscle.

It may be noted that the precise anatomical arrangement of the posterior prostatic space of Proust depends on the development of the rectogenital septum (Denonvilliers' fascia) and its caudal limit, which may be variable. The septum is sometimes absent. Embryologically this septum is a fusion of the peritoneal mesothelial layers with their immediate supporting basement membranes forming a double-layered septum between the prostate and rectum extending to the pelvic floor.

Uhlenhuth in his detailed study of the derivation of the rectogenital septum concludes that this septum is of peritoneal origin, and that it can usually be demonstrated as a separate membrane independent of the fascial capsules of the adjacent viscera in both sexes. He also emphasizes that the depth of the rectovesical pouch which marks the upper end of the septum is considerably variable.

Tobin and Benjamin have also described the embryological anlages of this septum and they also confirm the earlier investiga-

tion of Cuneo and Veau in regard to its peritoneal derivation, in contrast to its fascial origin described by Wesson.

Inasmuch as the rectogenital septum is a double-layered membrane, there are three potential lines of cleavage between the rectum and prostate: 1) that between the posterior layer of Denonvilliers' fascia and the rectal wall—the least desirable; 2) that between the two layers in the retroprostatic space of Proust—the preferable one; 3) that between the anterior layer and the prostatic tissues (fig. 105).

From the pelvic approach it may be noted that it is necessary

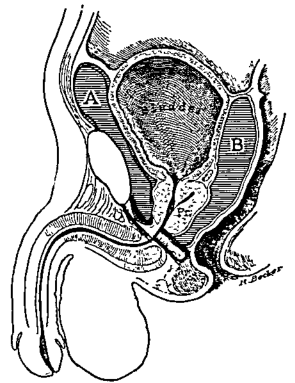


FIG. 104. The posterior prostatic space. The drawing represents the two most common sites for the localization of pus about the bladder and prostate. (After Culver and Baker.) A, abscess in the prevesical space (space of Rezius), and B, abscess in the retrovesical separable space (posterior periprostatic space). (Goldstein, A. E., and Abeshouse, B. S.: *Surg., Gynec. & Obst.*, 1929.)

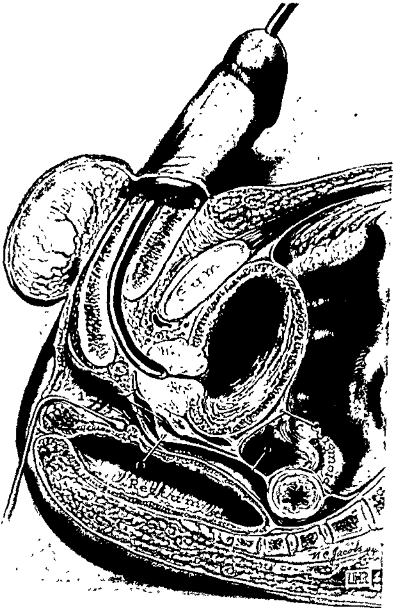


FIG. 105. Sagittal pelvic section of a male cadaver in which the Young prostatic approach was made. The anus and lower part of the rectum are retracted dorsally *within the incision. In this approach the rectal fascia was divided; part of it is* still attached to the central point of the perineum, the remainder covers the cephalic portion of the rectum. The peritoneum is elevated from bladder and

to divide the supragenital fascia before access is made to the prostate, seminal vesicles and vas, and that the firm attachment of the septum to the posterior lobe of the prostate must be divided to gain access to the retroprostatic space of Proust.

PERIPROSTATIC SPACES. These minor spaces of the anterior supralevator compartment are primarily of urologic interest. However, surrounding the urethra, prostate and seminal vesicles which comprise the common urologic foci for infectious and malignant processes, they are significant to secondary invasion of the perineopelvic spaces.

The Anterior Periprostatic Space. This is a small recess ventral to the prostate bounded on either side by the medial puboprostatic ligaments.

The Lateral Periprostatic Space. This space is the potential interval between the lateral aspect of the prostate and the supra-anal fascia covering the pubococcygeus muscle—the levator prostatae fibers of the levator ani. This space is of proctologic interest because it is continuous with the anterior compartment of the supralevator space (fig. 106).

Posterior Compartment Supralevator Space

This compartment contains the pararectal and retrorectal (presacral) spaces.

THE PARARECTAL SPACE. The pararectal space is a narrow but

cephalic portion of the rectum. The anterior layer of Denonvilliers' fascia is attached to the peritoneum and extends caudally between the seminal vesicles and prostate and rectal fascia to the superior layer of the urogenital diaphragm. This membrane adheres to the prostatic capsule at the junction of the ejaculatory ducts to the prostate. Other fibrous bands extend from the peritoneum to the seminal vesicles and bladder. As indicated by the arrows, cleavage planes may be made between: 1, the rectal musculature and rectal fascia (posterior layer of Denonvilliers' fascia); 2, the rectal fascia and the anterior layer of Denonvilliers' fascia; and 3, either this anterior fascial layer and the fibromuscular coverings of the seminal vesicles or it and the prostatic capsule. A sound is passed through the urethra, but the prostate is not shown retracted dorsally by the sound. When the prostate is so retracted, these fascial layers are compressed against the rectal musculature and dissection may lead into the rectum (Tobin, C. E.: *Surg., Gynec. & Obst., 80:* 373.)

important recess extending from the rectovaginal or rectovesical (male) septum along the inferolateral border of the rectum on the superior surface of the pubococcygeus muscle to the anterior reflection of the presacral fascial wing of the rectum. This space, somewhat larger in the female, is the usual location for the supralevator abscess in this sex (fig. 98).

In the male, on the other hand, the anterior compartment or one of its minor spaces in relation to the prostate or seminal vesicles is more commonly involved.

The roof of the pararectal space in both sexes is the peritoneum of the pararectal fossa which is more extensive in the female.

The pararectal space is separated from the retrorectal space by the presacral wing of the hypogastric sheath and its caudal rectal septum.

THE RETRORECTAL (PRESACRAL) SPACE. This space is the interval between the parietal pelvic fascia covering the piriformis, coccygeus and pubococcygeus muscles and the presacral wing of the hypogastric sheath. Cranially the ventral wall of this space is formed primarily by the presacral wing. Caudally, where the

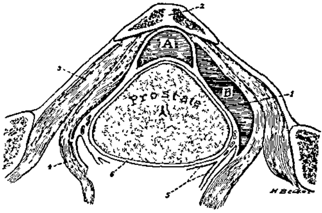


FIG. 106. Abscess in the anterior periprostatic space and in the superior pelvirectal space. (After Aversenq and Dieulafe.) 1, lateral periprostatic fascia; 2, pubic bone; 3, obturator internus muscle; 4, levator ani muscle; 5, posterior periprostatic fascia or fascia of Denonvilliers (2 layers); 6, capsule of prostate gland; A, abscess in the anterior periprostatic space; B, abscess in the superior pelvirectal space. (Goldstein, A. E., and Abeshouse, B. S.: *Surg., Gynec. & Obst.*, 1929.)

posterior rectal wall lies on a more or less horizontal plane, the ventral wall of the retrorectal space is also formed by the rectal fascial capsule which is the posterior leaf of the presacral wing after its splitting and envelopment of the rectal ampulla (fig. 107).

Caudally this space extends to the supra-anal fascia covering the aponeurotic insertions of the pubococcygei muscles into the lower sacrum and coccyx. The lateral and caudal extensions of the aponeurotic plates of the pubococcygei muscles fuse with the parietal pelvic fascia covering the coccygeus muscle and form the strong fascial layer commonly referred to as the fascia of Wal-

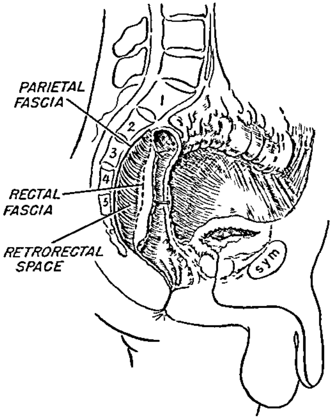


FIG. 107 The retrorectal space (presacral space). Redrawn from Bacon, H. E.: *Anus, Rectum and Colon*. Philadelphia: Lippincott, 1949.

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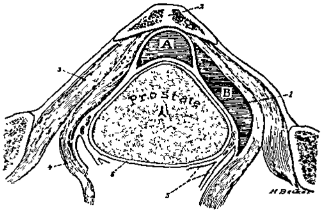


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supra-anal fascia-parietal fascia. The inferior layer he described as largely muscular and composed of fleshy fascicles from the levator muscle proper. The hiatus between these superior and inferior layers extending around and posterior to the rectum is referred to by Courtney as a "posterior levator space."

This somewhat arbitrary terminology of superior and inferior layers to fascial and muscular extensions from the levator ani components is somewhat confusing in comparison with other anatomical descriptions.

Superior and inferior layers of the levator ani muscle were originally referred to by Holl and later by Kohlrausch, and more recently described by Uhlenhuth in great detail. These anatomists point out that the splitting or layering of the levator ani muscle starts at the origin of the muscles and that both layers are distinctly muscular and separable throughout (fig. 60).

Courtney has also described lateral fascial reflections from the superior layer of the iliococcygeus muscle which fuse into the rectococcygeus muscle, and he therefore considers the term "iliorectococcygeus" as more descriptive than rectococcygeus. In our dissections the rectococcygeus is itself an already confused "muscle," is considered variable and is usually fused with the rectal capsule and the supra-anal fascia with but little anatomic relation to the iliococcygeus muscle.

Clinically it is conceivable that a "posterior levator space" or other potential hiatuses around the anorectal junction may become infected with subsequent abscess formation. However the intimate relation of such spaces to the roof of the ischiorectal space, the immediate supralevator space and the retrorectal space would appear to offer considerable difficulty in the differential diagnosis as to the exact space involved or the site of the primary infectious focus. These deep abscesses are commonly well advanced before examination and the indurated bulging rectal wall usually effaces all recognizable landmarks.

Our experience with deep ischiorectal and supralevator abscesses would tend *to emphasize that the exact anatomical loca-*

deyer, a strong support for the anorectal junction and the rectal ampulla.

Laterally the retrorectal space extends to the medial leaf of the hypogastric sheath along the origin of the presacral wing which forms a strong lateral barrier. Retrorectal abscesses are more apt to rupture into the rectum or penetrate the levator ani muscle than to burrow laterally into the supralevator spaces or through the obturator foramen to the subserous peritoneal spaces or the sciatic notches.

Cranially the retrorectal space becomes continuous with the prevertebral retroperitoneal tissues.

The retrorectal space is bridged by rather firm fascial stalks (Jonesco) which arise from the parietal fascia overlying the anterior sacral foramen. These stalks insert into the presacral wing and into the capsule of the rectum. They convey the parasympathetic fibers of the sacral nerves and branches from the sympathetic ganglia. An anastomotic network of these nerve fibers sandwiched in between the layers of the presacral wing forms the pelvic ganglion. Branches from this ganglion pass into the inferior hypogastric wing and supply the urogenital organs. The rectum is supplied by fibers which pass caudally between the rectal capsule and its musculature.

The extent of physiological disturbance in the pelvic viscera following abdomino-perineal excision of the rectum depends somewhat on the destruction of this ganglion and its connections with the hypogastric and hemorrhoidal plexuses. The surgical approach to the retrorectal space and to this ganglion is not well established.

"The Posterior Levator Space" (Courtney)

Courtney has described a splitting of the components of the levator ani muscle into superior and inferior layers near their junction with the rectal wall. The superior layers he describes as a more or less aponeurotic layer formed by cordlike fascial extensions from the superior fascia of the levator ani muscle and the

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tion is not definitely determined until these infections are actually drained and digitally explored.

The recognition of a "posterior levator space" as a clinical entity in the already confused subject of anorectal abscess would appear to require further study and adequate clinical and anatomical evaluation.

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pathways of spread. Moreover the visceral nerve supply has a basic anatomical relationship to the fascial planes and the perivascular sheaths.

Since cancer metastasis is largely through the lymphatics and veins of the neurovascular sheaths, it appears that their recognition as one of the basic components of the visceral pelvic fascia would tend to improve the surgical anatomy of the pelvis.

According to Hayes the adult abdomino-pelvic fasciae develops from three embryonal tissues: "the young mesenchymal tissue intimately associated with the developing musculature of the parieties; the loose mesenchymal tissues ubiquitously distributed between the developing intrinsic fascia of the muscles and the maturing celomic epithelium; and the celomic epithelium itself" (fig. 108).

The term fascia has acquired both an anatomical and a surgical interpretation. It will be used in this text in its broad anatomical sense, including perivascular, perivisceral, ligamentous and subserous tissues. Restriction of the term to comprise only connective tissue in direct relation to muscle is surgical rather than anatomic.

The endopelvic fascia is now generally recognized as divisible into parietal and visceral portions.

The parietal portion lines the entire pelvic cavity and its musculature. Functionally it affords the means of attachment of the components of the visceral fascia to the pelvic wall and the pelvic diaphragm. It is hence primarily aponeurotic in character. The parietal fascia also forms a fascial partition between the larger somatic nerve trunks and the pelvic musculature.

The visceral pelvic fascia forms the perivascular sheaths, the visceral capsules, the intervisceral supports and the less important diffusely distributed "filler in" or areolar tissue of the pelvis.

The parietal endopelvic fascia[1] may conveniently be divided into a supralevator and an infralevator plane.

[1] The parietal fascia is sometimes referred to as the deep and the visceral as the superficial pelvic fasciae.

CHAPTER VII

The Pelvic Fascia

General Considerations

Conflicting anatomical descriptions with a confused terminology and a disagreement concerning its anatomical components has made the pelvic fascia a difficult subject for the teacher and student and of limited application to the surgeon. The perivascular sheaths, for example the hypogastric sheath and its several wings, recently re-emphasized by Uhlenhuth, are yet to be generally recognized as distinct components of the visceral pelvic fascia.

The pelvic fascia is *functionally a dynamic mechanism* of pelvic support with abrupt changes in its gross character, tensile strength and histologic content. It is hence difficult to describe and understand. It is sometimes loosely referred to as an undifferentiated "subserous tissue" with no distinction as to parietal or visceral portions. Such oversimplified descriptions would have but little teaching value and no surgico-anatomic application.

Knowledge of the fascial planes is essential to accurate mobilization and conservation of the important pelvic structures. *The complex fascial relations are significant to the pathogenesis and localization of pelvic suppurative processes* with their residual deep fistulous or sinus formations. Inasmuch as the fascia largely defines the pelvic and perineal spaces it is of particular importance to the proctologist.

The increasing radical approach to pelvic cancer surgery demands a detailed knowledge of possible lymphatic and venous

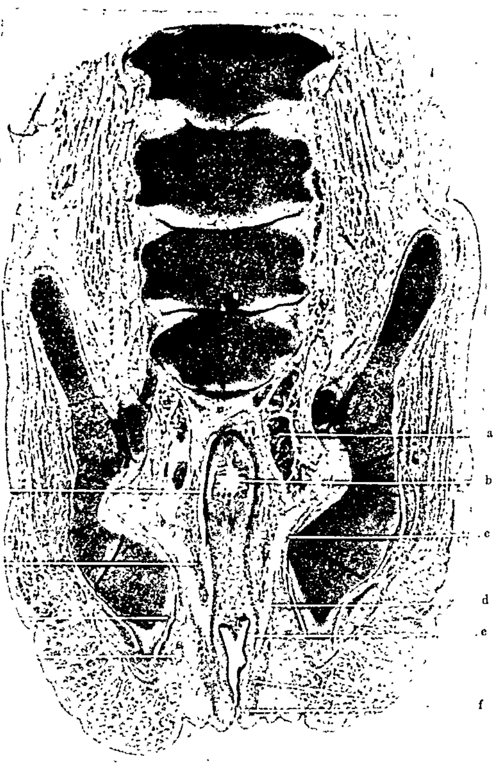
The supralevator plane:
The supra-anal fascia.
The infralevator plane:
The obturator fascia
The infra-anal fascia (anal fascia)
The perineal fasciae
Superficial
Deep (Colles' fascia)
The superficial perineal compartment
The urogenital diaphragm (triangular ligament, deep perineal compartment, etc.)
The visceral endopelvic fascia (the essential components of this fascia are):
The perivascular-neurovascular sheaths
The hypogastric sheath
Superior hypogastric wing
Inferior hypogastric wing
Presacral wing
The fascia endopelvina
The rectogenital septum
Fascial capsules of the viscera
The subserous fascia

PARIETAL ENDOPELVIC FASCIA

Supralevator Plane

SUPRA-ANAL FASCIA (*Levator Fascia; Superior Pelvic Diaphragmatic Fascia, Etc.*) This strong fascial layer surrounds the pelvic viscera as they pass through the pelvic diaphragm, and fusing with their fascial collars and their outer musculature it forms an important supportive mechanism for the visceral outlets.

FIG. 108. Frontal section of the pelvis (human embryo 80 mm., approx.). a, umbilical artery; b, sigmoid colon; c, supraanal fascia; d, levator ani muscle; e, mesenchymal tissue around the rectum; f, external anal sphincter muscle; g, pudendal stalk; h, obturator internus muscle; i, fusion fascia around the rectum; k, lateral cul-de-sac of the rectum.


a
b
c
d
e
f
k
i
h
g

coccygeus muscle, the sacral fascia also splits in a similar manner forming the supra-anal fascia on the upper surface of the coccygeus muscle and the infra-anal fascia below it. It may be noted that the arcus tendineus of the levator ani muscle—the "white line" and its continuation along the upper margin of the coccygeus muscles—defines the entire pelvic origin of the supra-anal fascia (fig. 62). pg. 121.

Continued into the pelvis from the transversalis fascia anteriorly, the supra-anal fascia spans the infrapubic interval between the arcuate ligament and the small transverse ligament of the pelvis formed by the fused anterior margins of the urogenital diaphragm. This interval conveys the dorsal vein of the penis or clitoris and the dorsal nerve. The supra-anal fascia then spans the interval between the crura of the pubococcygeus muscles and coursing around their free medial margins it fuses with the deep layer of the triangular ligament—urogenital diaphragm. This fusion forms a strong aponeurotic origin for these muscles. The supra-anal fascia then has important relations to the inferior and lateral surfaces of the prostate. The prostate has five surfaces: two lateral, one superior, one posterior and one inferior commonly divided into pubic and perineal surfaces. The pubic and posterior or rectal surfaces of the prostate are free while the perineal surface is attached to the middle third of the triangular ligament by the supra-anal fascia. After fixing and surrounding its apex the supra-anal fascia envelops the prostate and blends with its capsule. Antero-laterally to the prostate and bladder it fuses with the fascia endopelvina—arcus tendineus fascia pelvis—to form strong pubic attachments for these viscera.

Continuing from the posterior surface of the triangular ligament the supra-anal fascia surrounds the rectum, blends with its capsule and longitudinal musculature and contributes fibro-muscular extensions to the formation of the proctologically important conjoined longitudinal muscle of the anal canal (p. 71).

In the female the interposition of the vagina between the urethra and the rectum modifies the relations of the supra-anal fascia.

The supra-anal fascia originates along the pelvic origin of the levator ani muscle—the arcus tendinous levator ani or white line of the pelvis. Along this irregular white line the iliac and obturator fasciae divide into the supra-anal fascia reflected over the upper surface of the levator ani and the infra-anal fascia reflected over the lower surface of this muscle. The obturator fascia continues downward over the lower third of the obturator internus muscle forming *the lateral boundary of the ischiorectal space (fig. 109).*

Posterior to the ischial spines, along the upper margin of the

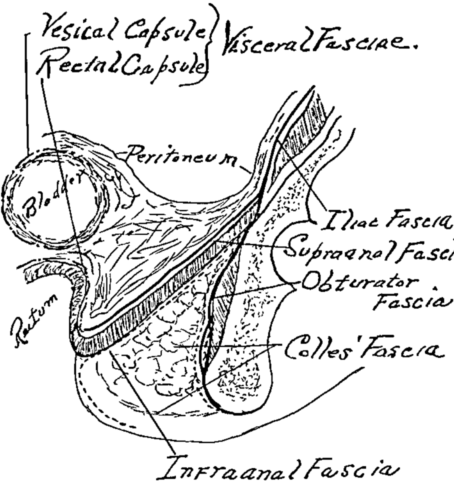


FIG. 109. The parietal pelvic fasciae (red). Schematic.

anal fascia becomes continuous with its capsule (the fascia vesicalis), with the vaginal capsule (the fascia vaginalis) and with the deep layer of the triangular ligament along the medial margins of the pubococcygeus muscles.

Lateral to the vesicovaginal junction a strong lamina of the *visceral* fascia fuses with the supra-anal fascia to form the vesicocervical ligaments connecting the visceral capsules of the bladder and cervix. These ligaments, important in gynecologic surgery, have been referred to as the paravaginal fascia, the uterovesical ligaments, the "pillars of the bladder" (Curtis) etc. They separate the space of Retzius from the vesico-vaginal space.

Continuing posteriorly the supra-anal fascia fuses with the rectal capsule—rectal fascia—and its longitudinal musculature as described for the male, and covering the anococcygeal raphe or levator plate it continues upward over the anterior surface of the sacrum as the presacral *parietal* fascia.

It should be noted here that the supra-anal fascia and the fascia endopelvina (arcus tendineus fascia pelvis), visceral fascia, although described as separate structures, combine to form the true ligamentous bands to the prostate and bladder, e.g., the anterior and lateral puboprostatic (pubovesical in the female), the medial and lateral vesical ligaments. The fascia endopelvina extends through the supra-anal fascia as a strong connective tissue shelf from the pubic arch to the ischial spines. It serves as a separate line of attachment for the visceral fascial wings and their ligaments to the pelvic wall.

The supra-anal fascia, together with the pubococcygeal crura and the lateral wings of the triangular ligament form the important surgical unit in restoration of the female perineum. The pubourethral and vesicocervical ligaments are similarly important in the surgical correction of urinary incontinence in the female.

Infralevator Plane

The infralevator plane of the parietal pelvic fascia includes the obturator fascia, the infra-anal fascia and the perineal fasciae.

Reflected from the pubic tubercles and the arcus tendineus of the levator ani muscle, it covers the superior surface of the levator ani muscles just above the deep layer of the triangular ligament. Passing above and behind the urethra it forms a part of the musculofascial wing-like supports which encircle the urethra from one pubic bone to the other—the pubourethral fascia, pubourethral ligaments (Curtis) (fig. 110). The small hiatus between the arcuate ligament and the pubis conducts the dorsal veins and nerve as in the male.

Continuing posteriorly to the neck of the bladder the supra-

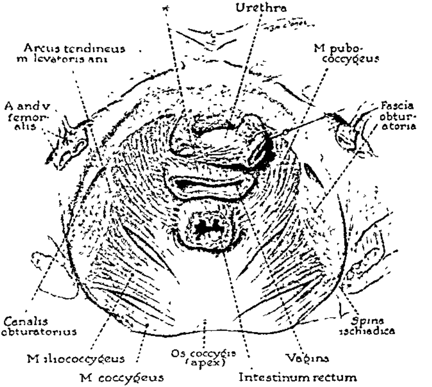


Fig. 110. The pubo-urethral fascia. The fascial layers have been removed and the viscera excised to a lower level, in order to demonstrate the muscular constituents of the pelvic floor and the relations of these to the viscera. The urethra has been pulled aside to show the course of the levator fibers on its posterior aspect and the nature of the "pubo-urethral ligament" indicated by an asterisk. (Curtis, A. H., Anson, B. J., and McVay, C. B.: *Surg., Gynec. & Obst.*, 1939.)

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Continuing posteriorly to the neck of the bladder the supra-

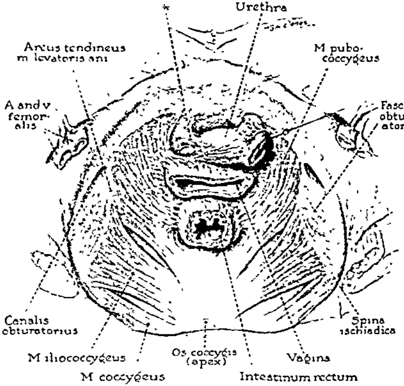


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Fig 112 The superficial perineal fasciae. (Davies, J. W.: *Surg., Gynec. & Obst.*, 1934.)

upper margin of the coccygeus muscle. A reflection of the obturator fascia housing the pudendal vessels and nerves along the lower and lateral boundary of the ischiorectal space is referred to as the fascia lunata (Alcock's canal).

Infra-anal fascia. The anatomists usually describe the iliac fascia as splitting into three layers along the arcus tendineus of the levator ani muscle—the white line: one above the levator, the supra-anal or supralevator fascia; one continuing down the pelvic

The superficial and deep perineal pouches or compartments may also be included here.

OBTURATOR FASCIA. The obturator fascia covers the obturator internus muscle, forms its sheath and through its attachments to the ischial and pubic rami anchors this muscle to the bony foramen (figs. 109 and 111).

Anteriorly it spans the pelvic aperture as the lower layer of the triangular ligament (deep perineal compartment). Posteriorly it becomes continuous with the parietal pelvic fascia along the

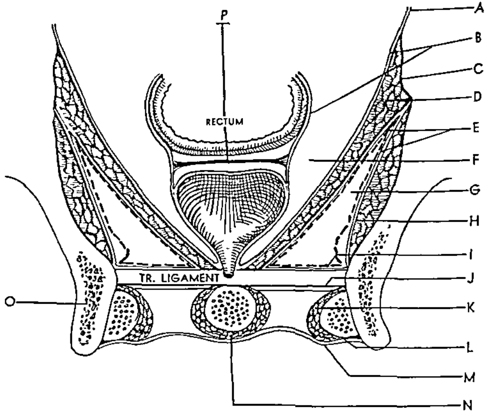


FIG. 111. The infraanal fascia (red). A, iliac fascia; B, supra-anal fascia; C, levator ani muscle; D, arcus tendineus levator ani; E, infraanal fascia; F, supralevator space; G, ischiorectal space; H, obturator fascia; I and J, superior and inferior layers of the urogenital diaphragm; K, ischiocavernosus muscle; L, inferior perineal fascia (Gallaudet); M, Colles' fascia; N, bulbocavernosus muscle.

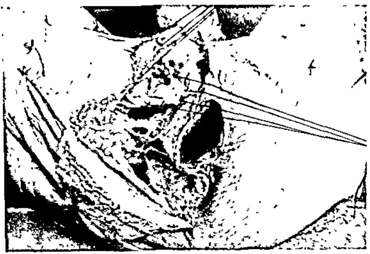


FIG 113. Camper's and Colles' fasciae. The superficial layer (Camper's) and the deep layer (Colles') of the perineal fasciae are suspended on black threads. Note the strong attachment of Colles' fascia to the pubic ramus

vessels and nerves forms a neuro-vascular sheath—the inferior hemorrhoidal stalk (fig. 56).

PERINEAL FASCIAE. The perineal fasciae consist of a superficial subcutaneous layer (panniculus adiposus) and a deep membranous layer. The former, unnamed, is usually considered as corresponding to Camper's fascia of the abdominal wall; the latter, Colles' fascia, corresponding to Scarpa's fascia (fig. 113).

Throughout the perineum the subcutaneous layer varies considerably in texture and fat content. In the scrotum it contains muscle fibers, the dartos, with little fat. Over the urogenital triangles the fat content gradually increases and in the anal triangles it forms the fatty layer of the perianal space. Its texture then changes somewhat abruptly to the large soft fatty globules characteristic of the ischiorectal spaces and their anterior extensions above the triangular ligament.

Superficial. Laterally over the ischial tuberosities the superficial fascia contains fibrous tough fascicles which connect the skin to the underlying bone. A fibrous bursa lies directly over the ischial tuberosity.

wall as the obturator fascia; and the third below the levator muscle—the infra-anal or anal fascia.

The infra-anal fascia is a comparatively thin sheet of fascia extending from the tendineus arch—white line—and covering the inferior surface of the pelvic diaphragm. It is continued around the anal canal as the circumanal fascia. It lines the ischiorectal spaces covering the obturator fascia and the fascia lunata (Alcock's canal). Above the triangular ligament—urogenital diaphragm—it is reflected into the anterior recesses of the ischiorectal spaces and attaches to the medial margins of the puboischial rami fusing with the obturator fascia. This fused fascia after splitting forms the two layers (superior and inferior urogenital fasciae) of the triangular ligament; the upper layer is usually considered as derived from the infra-anal fascia and the stronger inferior layer from the obturator fascia. This derivation is as yet equivocal (fig. 111).

The infra-anal fascia is also reflected over the superficial perineal muscles above Colles' fascia and has been termed the inferior perineal fascia (Gallaudet) (fig. 111).

It may be noted that the supra-anal and infra-anal fasciae form a sheath or compartment for the levator ani and coccygei muscles. Along the medial borders of the pubococcygeus muscles these fascial planes become continuous and fuse into the superior layer of the triangular ligament and into the central perineal tendon. Behind the anal canal and below the levator plate the infra-anal fascia lines the deep postanal or posterior communicating space.

Posteriorly the infra-anal fascia fuses with the obturator fascia along the upper border of the coccygeus muscle and the lower margin of the sacrospinous ligament. This line of fusion marks the posterior limit of the ischiorectal space as already noted. The obturator fascia then continues upward as the presacral parietal fascia as already mentioned.

The infra-anal fascia reflected over the inferior hemorrhoidal

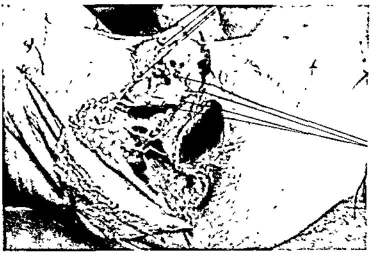


FIG. 113 Camper's and Colles' fasciae The superficial layer (Camper's) and the deep layer (Colles') cf the perineal fasciae are suspended on black threads. Note the strong attachment of Colles' fascia to the pubic ramus.

vessels and nerves forms a neuro-vascular sheath—the inferior hemorrhoidal stalk (fig. 56).

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Superficial. Laterally over the ischial tuberosities the superficial fascia contains fibrous tough fascicles which connect the skin to the underlying bone. A fibrous bursa lies directly over the ischial tuberosity.

It may be useful to point out that the ischiorectal fossa is divided into two spaces by the lateral extensions of the conjoined longitudinal muscle—transverse septum of the ischiorectal fossa (Milligan). These superimposed spaces, the perianal and ischiorectal, are of proctologic significance. The perianal space contains the well defined and closely meshed fibrofatty layer of the superficial fascia, in contrast to the large fatpads of the ischiorectal space. The perianal space also contains the subcutaneous portion of external sphincter ani muscle, the terminal caudal extensions of the conjoined longitudinal muscle (corrugator cutis ani muscle), the external hemorrhoidal veins and the perianal nerve plexus.

In the female the superficial fascial layers are modified by the external genitalia. The subcutaneous layer of the labia majora contains the fatty diverticular process which rests on the deeper fascial layer—Colles' fascia. This fatty process distinct from the surrounding fascia is the homologue of the scrotum and, as described by Anson and Ashley, contains the inguinal parieties in rudimentary form.

In the anal triangles the superficial fascial layers are essentially as described in the male.

Deep (Colles' Fascia). Somewhat variable in texture and density, this fascia has conflicting descriptions. It is sometimes described as including the superficial or subcutaneous layer (Tobin). In our dissections several fascial layers are usually readily demonstrable because of the diffuse attachments between the superficial and deep layers.

The main layer of Colles' fascia has a firm attachment to the pubic rami. In the male it spreads medially across the urogenital triangle, forming the floor of the superficial perineal compartment containing the superficial perineal muscles. After fusing with the infra-anal fascia it attaches to the posterior margin of the triangular ligament. Anteriorly it becomes the superficial fascia or dartos of the penis and affords attachment for the dartos of the scrotum

and its medial septum which separates the superficial perineal compartment from the scrotal cavities.

Urine and other extravasates entering the superficial perineal compartment are closely confined by the main leaf of Colles' fascia and are prone to reach the abdominal fascial planes rather than the scrotal cavities. The roof of the superficial perineal compartment is the lower layer of the triangular ligament.

Buck's fascia and Colles' fascia are commonly confused, particularly in their relation to the penile muscles and the tunica albuginea. The recent detailed investigations of Uhlenhuth and his co-workers have clarified these equivocal layers. On the shaft of the penis Buck's fascia lies below Colles' fascia (penile dartos) and is closely applied to the albuginea as it extends posteriorly both on the urethra and the crura deep to the penile muscles. As emphasized by Uhlenhuth, Buck's fascia is a single continuous and independent fascial sheath for the entire urethra in its penile as well as perineal portions. However, the single cylindrical sheath covering both corpora cavernosae represents a fusion at the penile junction of the separate fascial layers of Buck's fascia covering the crura (fig. 114).

A reflection of Colles' fascia below the bulbocavernosus muscle is referred to as its "deep septum" which forms a fascial sheath for this muscle and separates it from the underlying fascia of Buck and the albuginea.

In the female the disposition of Colles' fascia is modified by the interposed vagina between the lateral wings of the triangular ligament. It spans the perineum in front of the anal canal, covers the transverse perineal and paired bulbocavernosus muscles and is attached to the inferior layer of the triangular ligament as in the male.

Superficial and deep perineal pouches or compartments. These are mentioned here for the sake of completeness. They are fully described in Chapter I (p. 12).

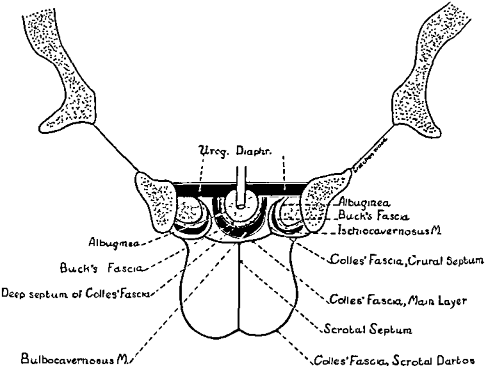


FIG. 114. Frontal section through perineum, showing relations of Buck's fascia, Colles' fascia and penile muscles. (After Uhlenhuth.)

VISCERAL ENDOPELVIC FASCIA

As its name implies, the visceral endopelvic fascia has a more or less intimate anatomical and functional relationship to the pelvic viscera.

Its main components include the hypogastric sheath and its wings; the fascia endopelvina; the visceral capsules; the recto-genital septum and the loose areolar or "filler in" tissue ubiquitously distributed throughout the pelvis.

The perivascular sheaths—the hypogastric sheath and its several wings—recently reemphasized by Uhlenhuth and his co-workers are not generally recognized or described as components of the visceral fascia. They are admittedly difficult to understand and to demonstrate.

However with an increasing trend in radical pelvic surgery it

is anticipated that their surgico-anatomical importance may receive wider recognition. Short descriptions of the hypogastric sheath and its wings have been included.

Perivascular-Neurovascular Sheaths

The importance of the perivascular sheaths in providing a supportive mechanism for the viscera was initially described by Cameron and has been indirectly referred to by many subsequent observers.

Peham and Amreich in their classical *Gynaekologische Operationslehre* also emphasized the inseparable relation of the fascia to the vascular supply; these authors used the largest perivascular sheath in the pelvis, the hypogastric, as the basis for their description of the pelvic connective tissue. To emphasize its functional importance they termed the hypogastric sheath and its root the *vertical* "ground-plate" of the visceral fascia. The aponeurotic fascia endopelvina—the arcus tendineus fascia pelvis—they termed the *horizontal* ground-plate.

Peham and Amreich made no distinction between these basic ground plates. However, as emphasized by Uhlenhuth, they are essentially different structures, the horizontal plate being entirely aponeurotic and the vertical entirely perivascular and periureteral

Uhlenhuth, in his recent admirable presentation from which we have drawn freely, gave a precise and detailed description of the perivascular sheaths or wings arising from the hypogastric sheath as well as the fascial extensions from the fascia endopelvina. He emphasized that the perivascular sheaths and the fascial wings have a well defined anatomic pattern in relation to the several viscera and their blood supply, and that they divide the subperitoneal pelvic area into separable fascial spaces of surgical and pathogenic importance.

It is re-emphasized that the fascial wings arising from the hypogastric sheath are essentially perivascular sheaths with incidental supportive function, while the fascial wings arising from

the visceral capsules and attached to the pelvic wall and the fascia endopelvina are primarily ligamentous supports. This is fundamental to pelvic dynamics.

HYPOGASTRIC SHEATH. This membranous sheath forms a strong fascial investment for the anterior division of the hypogastric vessels; their main branches and the ureter. Its root of origin extends along the *parietal* pelvic fascia and corresponds to the axis of the hypogastric artery approximatey along the line extending from the dorsal border of the ischial ramus to the ischial spine (fig. 115). As already noted, it represents the vertical anchorage or ground plate for the viscera, in contrast to the fascia endopelvina, the horizontal aponeurotic anchorage line with which it is continuous (fig. 115). It is roughly triangular in outline, with anterior and posterior layers between which the ureter, vessels, nerves and lymphatics are contained (fig. 116).

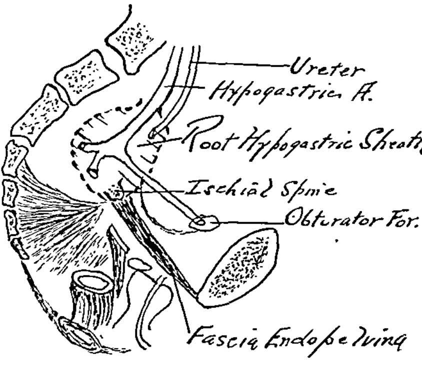


FIG. 115. Root of the hypogastric sheath (schematic).

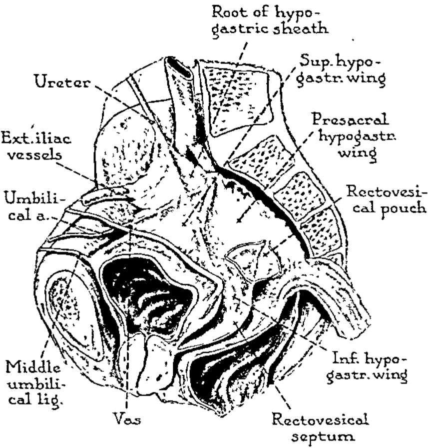


FIG. 116 The hypogastric sheath. Right half of pelvis of a white male, aged 69 years. Peritoneum removed everywhere except for the rectovesical pouch and septum. The hypogastric sheath is seen in its entire extent. The vas deferens passes across the superomedial surface of the superior hypogastric wing and is thus excluded from the space of Retzius. (After Uhlenhuth.)

Passing anteriorly, the hypogastric sheath is divided by the bladder into separate wings—the superior and inferior hypogastric wings (fascia hypogastrica superior and inferior).

Posteriorly it gives off an extensive double layered wing extending across the front of the sacrum, the presacral wing.

Superior Hypogastric Wing. The superior hypogastric wing extends anteriorly along the superolateral border of the bladder

and splits into superior and inferior layers. The superior layer becomes continuous with the capsule and subperitoneal tissues over the superior aspect of the bladder. The inferior layer becomes continuous with the capsule at the inferolateral aspect of the bladder (fig. 117).

From the superior border of the bladder the superior hypogas-

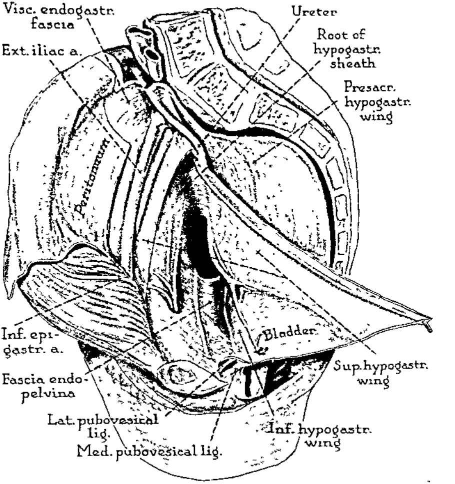


FIG. 117 The superior hypogastric wing. Right half of pelvis of female. Peritoneum largely stripped away. Superior hypogastric wing cut away from its lateral attachment. Bladder pulled medially and forward. Lateral compartment of space of Retzius exposed to view. (After Uhlenhuth)

tric wing extends laterally winglike to the pelvic wall above the space of Retzius and becomes continuous with the subserous fascia of the iliac fossa. It fuses into the sheath of the iliac vessels and posteriorly with the substance of the infundibulopelvic ligament of the ovary. Anteriorly it becomes continuous with the umbilical sheath. The superior hypogastric wing contains the superior vesical branches of the umbilical artery and veins. In the male the vas extends along this wing to reach the retrovesical space.

Peham and Amreich refer to the superior hypogastric wing as the vesico-hypogastric fascia. They classify it as a loose connective tissue sheet which joins the vesical fascia and roofs in the space of Retzius.

The older anatomists referred to this wing as the lateral "false" ligament of the bladder, primarily because it contained the subperitoneal areolar layer, or membrana cellulosa. Curtis has drawn attention to the fact that over the superior surface of the bladder the subperitoneal tissue is an indefinite layer. At the lateral margins, however, it forms a definite membrane, merging with with the vesical capsule to become an integral part of the superior hypogastric wing.

Inferior Hypogastric Wing. The inferior hypogastric wing originates in the caudal end of the hypogastric root. It has median and lateral extensions which have important relations to the bladder. The lateral extension inserts into the fascia endopelvina and the median extension into the inferolateral aspect of the bladder. This wing contains the ureter, the inferior vesical arteries, the large vesical venous plexuses and the autonomic nerves to the urogenital organs. It is continuous with and affords strong support to the musculofascial sheath for the ureter at the ureterovesical junction (fig. 118). This wing forms one of the true ligaments of the bladder—the inferolateral. It forms a partition between the retrovesical space and the space of Retzius.

Presacral Wing. This extensive wing is of particular proctologic interest in that it contains the branches of the pelvic ganglion, the superior hemorrhoidal vessels and the lymphatics and lymph

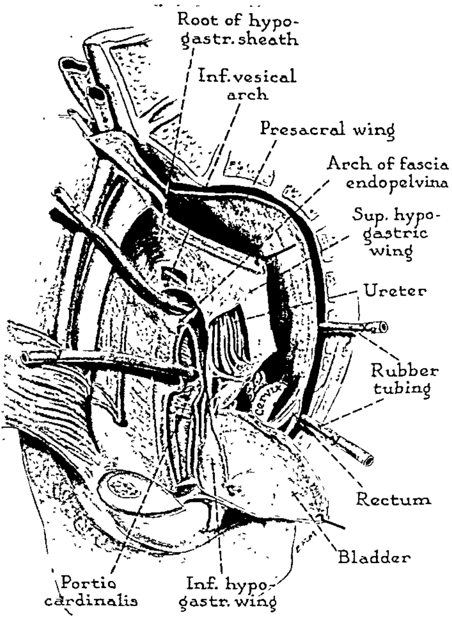


FIG. 118. The inferior hypogastric wing A: Same dissection as in fig. 117, but promontory tilted slightly forward, to permit full view upon floor and dorsal wall of lateral compartment of space of Retzius. Superior hypogastric wing cut away from lateral margin of bladder. Fascia endopelvina incised as far dorsally as ischial spine and arch of fascia endopelvina, to expose lateral true ligament of bladder

glands commonly involved in rectal carcinoma. It is likewise concerned in the formation of the retrorectal and pararectal spaces.

The presacral wing arises from the medial leaf of the hypogastric sheath and spans the interval in front of the sacrum between the parietal pelvic fascia and the rectum. It extends upward into the superior hemorrhoidal sheath. At its junction with the rectum it splits into anterior and posterior layers which form the rectal capsule or the fascia rectalis. The free caudal margin of this wing which follows the anterior curve of the rectal ampulla is attached to the fascia endopelvina (the caudal rectal septum—Peham and Amreich).

The retro-rectal space, continuous with the prevertebral space, is the large potential interval between the posterior layer of the presacral wing and the parietal pelvic fascia of the anterior wall of the sacrum (fig. 119).

The lateral boundary of this space is the line of junction of the presacral wing with the medial margin of the hypogastric sheath; caudally the retrorectal space terminates at the junction of the parietal sacral fascia with the supra-anal fascia at the level of the so-called rectococcygeus muscle.

Infectious processes in the retro-rectal space are usually confined by the firm lateral and inferior boundaries just described,

and the portio cardinalis of levator ani. B: Same dissection as in fig. 117 and left panel; windows have now been cut into the lateral layer of the inferior vesical arch and inferior hypogastric wing. Through the former the inferior vesical vein is visible. In the latter the ureter, the inferior vesical vessels and the uterine vessels are exposed to view; also it is seen that the vesical structures pass forward toward the bladder whereas the uterine vessels make an abrupt medial turn toward the uterus. The place where the uterine vessels turn medially represents the lateral root of Mackenrodt's ligament and lies at the same transverse level as the portio cardinalis of the levator ani. Body and fundus of uterus have been cut away. The fascia closing the space between the inferior vesical arch and the arch of the fascia endopelvina was incised and a piece of rubber tubing (x) was pushed through the incision. A similar piece of rubber tubing (y) was pushed through the floor of the lateral compartment of the space of Retzius, just dorsal to the portio cardinalis. Both tubes appeared in the retrorectal space, dorsal to the presacral wing and the rectum. (After Uhlenhuth.)

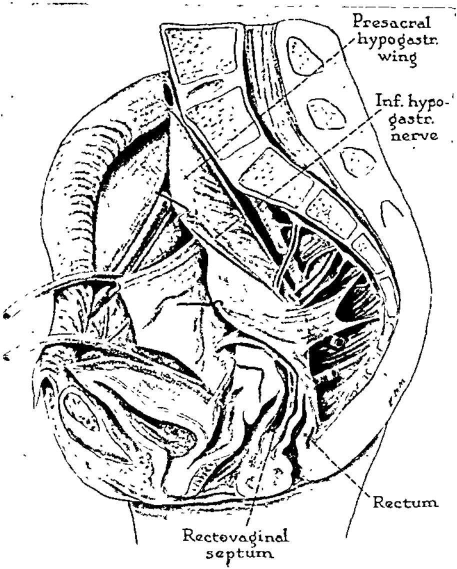


FIG. 119. The presacral hypogastric wing. The wing has been raised from the parietal fascia which is seen as it covers the coccygeus muscle, and has been reflected forward to permit a view into the retrorectal space. In this space are seen the autonomic nerves as they pass forward and laterally to pierce the dorsal layer of the presacral wing in order to enter the space between the two layers of the presacral wing and to join the pelvic ganglion; the latter has not yet been dissected out. The sympathetic branches arise from the sympathetic ganglia; the other branches are the parasympathetics, branches of the sacral nerves. In the retrorectal space are seen also the rubber tubes which were pushed through the floor of the space of Retizus to show the relationship between this latter space and the retrorectal space. (After Uhlenhuth.)



FIG 120. The superior hemorrhoidal sheath. The specimen shows the cranial extension of the presacral fascial wing into the superior hemorrhoidal sheath containing the superior hemorrhoidal artery, veins, lymphatics and subserous tissue.

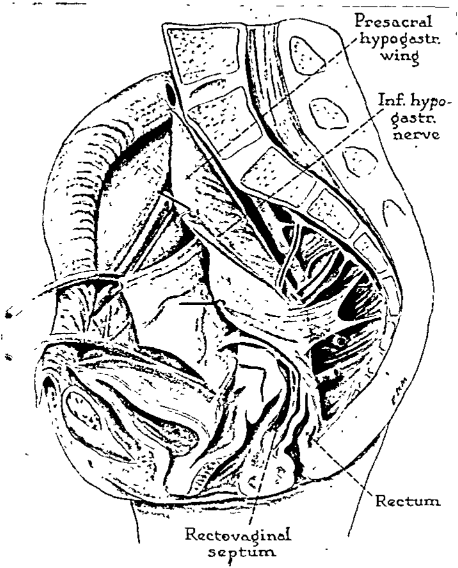


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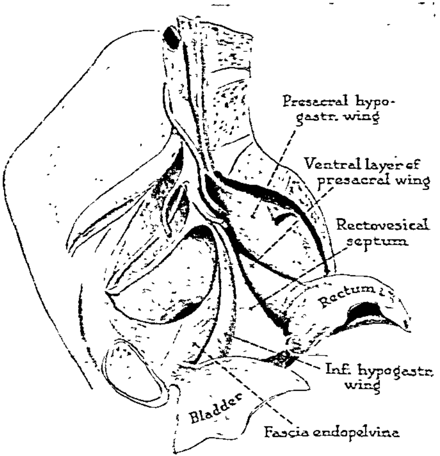


FIG. 121. The fascia endopelvina, right half of male pelvis. Peritoneum removed to expose elements of hypogastric sheath. Hypogastric root has been dissected away. Superior hypogastric wing was cut away. Bladder was cut away from inferior hypogastric wing and pulled out of the pelvis. Rectum pulled medially. The lateral margins of the inferior hypogastric wing, the rectovesical septum and the lateral fascial expansion of the rectal capsule are seen attached to the medial margin of the fascia endopelvina, like the leaves of a book. (After Uhlenhuth.)

ischial spine. This bony landmark may hence be considered as the pelvic anchoring point for the bladder.

Rectogenital Septum

This fascial septum may be conveniently included as an important component of the visceral fascia. Usually referred to as

and secondary extensions are more apt to rupture into the rectum or penetrate the levator muscle and gravitate to the infra-anal spaces. Their extension craniad is practically unhindered.

Fascia Endopelvina

This aponeurotic anchorage or ground plate extending through the supra-anal fascia is also called the arcus tendineus fascia pelvis, white line of the fascia endopelvina.

According to Uhlenhuth it is peculiar to man and is considerably variable in its tensile strength and histologic composition. The fascia endopelvina lies well below the arcus tendineus of the levator ani muscle with which it is commonly confused. It extends posteriorly on a horizontal plane from the pubovesical ligament to the ischial spine which marks its pelvic junction with the hypogastric sheath. This angle of junction is almost a right angle.

The fascia endopelvina is a strong fascial shelf which indirectly affords a pelvic attachment for the important fascial wings from the pelvic viscera, such as the lateral wing of the vagina, the rectovaginal septum, the inferior hypogastric wing, containing the ureter and the inferior vesical vessels, the ligaments of the prostate and bladder and the caudal rectal extension from the presacral wing (figs. 121 and 122).

Since the pelvic viscera are successively superimposed on a more or less horizontal plane, their superimposed fascial wings are attached to the fascia endopelvina in a fan-like manner (fig. 121).

These fascial wings in conjunction with the hypogastric wings form the pelvic fascial spaces which, although only potential, are surgically important.

At the ischial spines the fascia endopelvina forms a prominent fascial arch, the inferior vesical arch (fig. 118). This arch has been emphasized by Uhlenhuth because it may be palpated and reached without entering the peritoneum. The inferior hypogastric wing, which affords one of the main ligaments for the bladder, is indirectly attached to this fascial arch which in turn arises from the



FIG. 123. Denonvilliers' fascia (rectogenital septum) has been separated from the prostate and its margin fixed with black thread. Note the rectal capsular fascia caudad and the prostatic tissue craniad to the septum. Dissection by the author.

This septum in the male is of stronger and distinctly membranous texture in marked contrast to the less readily defined rectovaginal septum sometimes referred to as merely a layer of cellular tissue or part of the vaginal wall. In the male the septum is usually attached to the upper margin of the posterior lobe of the prostate and divides at this point into its so-called two layers: the anterior layer forms the true capsule of the posterior lobe of the prostate; the posterior layer continues caudally and inserts into the junction of the prostatic urethra with the superior urogenital fascia—upper layer of the urogenital diaphragm—at the level of the rectourethralis muscle. The space between these two layers is the retroprostatic space of Proust.

Laterally the rectogenital septum extends transversely across the pelvis, dividing it into an anterior urogenital and a posterior rectal compartment. It is attached caudally to the fascia endopelvina and to the inferior hypogastric wing.

No separate layers have been described for the female.

The caudal limit of the septum is variable, and in the male it has tended to confuse the surgical approach to the prostate and

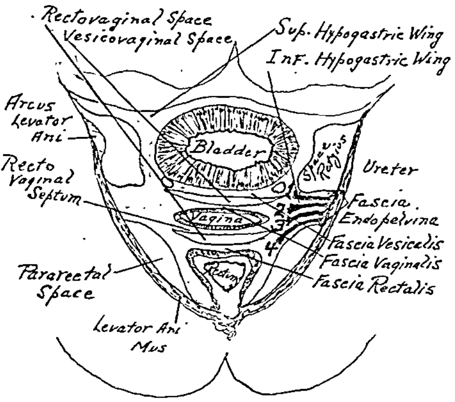


FIG. 122. The fascia endopelvina and its attachments (schematic and modified from Peham and Amreich). 1, the inferior hypogastric wing (ascending bladder septum—Peham and Amreich); 2, the lateral wing of the vagina (horizontal vaginal septum); 3, the rectovaginal septum; 4, the caudal extension of the presacral wing (descending rectal septum). In the male there are three fascial wings attached to the fascia endopelvina. Compare with fig. 121.

Denonvilliers' fascia (Tyrrell's fascia, etc.), it separates the prostate and seminal vesicles from the rectum. In the female it is termed the rectovaginal septum and separates the rectum and vagina (fig. 123).

Although its derivation is still somewhat equivocal, the recent investigations of Uhlenhuth and his co-workers, and those of Tobin and Benjamin, appear to refute the strictly fascial origin of this septum as advanced by Wesson in contrast to the peritoneal derivation originally advanced by Cuneo and Veau.

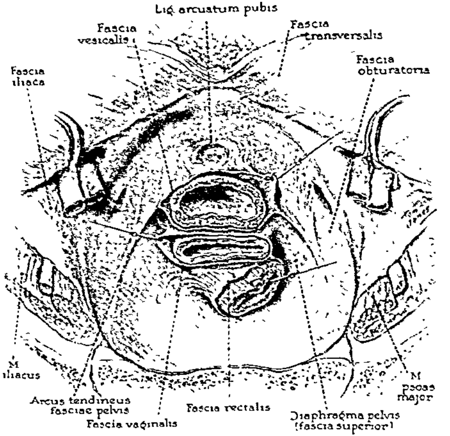


FIG. 124. Anterolaterally, the layers of the abdominal wall have been turned forward along a medial cut; posterolaterally, the alae of the ilium have been cut horizontally, together with the iliopsoas muscles and fasciae; posteriorly, the sacrum has been transected at the same horizontal level. All of the peritoneum and the subserous tissue have been removed to expose the fascia of the pelvis. Within the lesser pelvis, the organs have been transected, together with reflections of the diaphragmatic fascia, the endopelvic fascia. The vesical, vaginal, and rectal tubes of endopelvic fascia have been freed from their respective viscera and retracted. (Curtis, A. H., Anson, B. J., and McVay, C. B.: *Surg., Gynec. & Obst.*, Feb. 1939.) Note: the diaphragmatic fascia referred to by Curtis is the supra-anal fascia (parietal fascia; the endopelvic fascia is visceral fascia).

covered by an investment of fascia from the upper layer of the urogenital diaphragm.

FASCIA VESICALIS. Over the superior aspect of the bladder the fascial capsule is scarcely definable between the peritoneum and

vesicles. However, the septum is of surgical significance in that it partitions the rectum or vagina from the urogenital viscera and defines at least clinically the retrovesical, retroprostatic and rectovaginal spaces. Additional details on the rectogenital septum may be found in Chapter VI.

Fascial Capsules (Collars) of the Pelvic Viscera

Although they actually develop in situ, the capsules are usually described as a reflection or extension of the supra-anal fascia. They are also referred to as the fascia urethralis, vaginalis, rectalis and vesicalis etc.

The capsules directly invest the musculature of the several viscera and provide a medium for their attachment, particularly at the diaphragmatic level to the fascia endopelvina, to the supra-anal fascia, to the bony pelvis or to adjacent viscera. For example the fascia endopelvina (arcus tendineus fascia pelvis) affords attachment or the anchorage line for the lateral vaginal wing, the inferior hypogastric wing, the rectogenital septum, the pubo-prostatic and pubovesical ligaments etc. Each of the viscera has a separate capsule (fig. 124).

URETHRAL CAPSULE (FASCIA URETHRALIS). In the male the prostatic urethra is enclosed in a fascial reflection from the superior layer of the triangular ligament continuous with the supra-anal fascia which fuses with the prostatic capsule.[2] This capsule anchors the urethra to the urogential diaphragm and to the membranous urethral sphincter.

In the female the urethra has no distinct capsule inasmuch as its muscular wall is for the most part fused with that of the vagina.

Above the level of the urogenital diaphragm it is invested by muscular fibers from the pubococcygeus covered by the supra-anal fascia (the pubourethral ligaments). Below these ligaments the urethra, encircled by the sphincter membranacea muscle, is

[2] The capsule over the dorsal lobe of the prostate is formed by the anterior layer of Denonvilliers' fascia, while that of the ventral capsule of the prostate is a reflection from the supra-anal fascia.

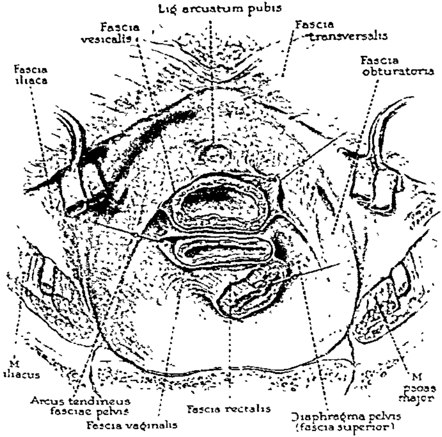


FIG. 124. Anterolaterally, the layers of the abdominal wall have been turned forward along a medial cut; posterolaterally, the alae of the ilium have been cut horizontally, together with the iliopsoas muscles and fasciae; posteriorly, the sacrum has been transected at the same horizontal level. All of the peritoneum and the subserous tissue have been removed to expose the fascia of the pelvis. Within the lesser pelvis, the organs have been transected, together with reflections of the diaphragmatic fascia, the endopelvic fascia. The vesical, vaginal, and rectal tubes of endopelvic fascia have been freed from their respective viscera and retracted. (Curtis, A H, Anson, B J, and McVay, C. B. *Surg., Gynec. & Obst.*, Feb. 1939) Note the diaphragmatic fascia referred to by Curtis is the supra-anal fascia (parietal fascia, the endopelvic fascia is visceral fascia).

covered by an investment of fascia from the upper layer of the urogenital diaphragm.

FASCIA VESICALIS. Over the superior aspect of the bladder the fascial capsule is scarcely definable between the peritoneum and

the musculature. At its superolateral margin, however, the capsule becomes well defined and fuses with the superior hypogastric wing. This is the vesicohypogastric fascia (Peham and Amreich), or the lateral "false" ligament of the bladder, which roofs in the space of Retzius (fig. 122).

Laterally and posteriorly the bladder capsule is denser and forms an attachment for the inferolateral ligament of the bladder. It is reflected over the inferior hypogastric sheath which encases the ureter and the neurovascular supply to the bladder and part of the prostate.

Anteriorly the vesical capsule affords attachment for the median and lateral pubovesical ligaments of the bladder.

UTEROVAGINAL CAPSULES. The fascial investment over the body of the uterus is thin and of little surgical importance. At the vaginal junction, however, the fascial capsule investing the cervix becomes dense and firm. At this level it becomes continuous or affords attachment to the round ligament, the uterosacral ligament and Mackenrodt's portion of the broad ligament—cardinal ligament of uterus. Its connections with the vesical capsule at this level form the vesicovaginal ligaments which separate the space of Retzius from the vesicocervical space (fig. 125 and 126).

Below the cervical ring the capsule invests the vagina and spreads laterally in wing-like extensions to form the un-named strong lateral fascial wings of the vagina which attach to the fascia endopelvina, the supra-anal fascia and the deep layer of the urogenital diaphragm. As Curtis points out, these wings follow the inclination of the vagina and form the large recto-uterine peritoneal fossa. Below the peritoneum covering these fossae are the pararectal spaces (supralevator space, posterior compartment) (fig. 122).

Below and posterior to the cervix, in the rectovaginal space, the opposed fascial capsules of the vagina and rectum are loosely separated by the controversial rectovaginal septum which attaches cranially to the peritoneum of the rectovesical pouch of Douglas and fuses caudally into the core of the perineal body.

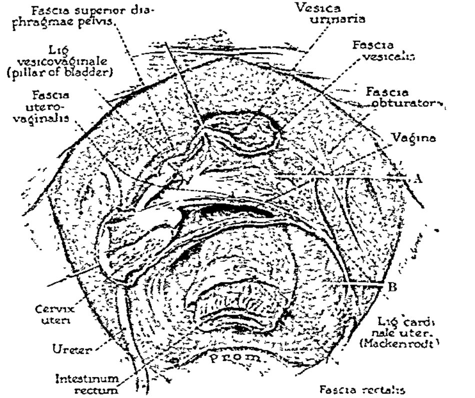


FIG. 125. Endopelvic fascia (visceral investments); ligamentous supports of the viscera The bladder has been cut down to the trigonal portion, leaving, however, the ureter on the left side The cervix of the uterus and the vagina (upper two-thirds) have been halved sagitally, the uterine collar of endopelvic fascia separated from the muscular wall On the right side a similar continuity is demonstrated—as is the relation of the fascial collar to the cardinal ligament. By drawing apart the bladder and the uterus, the fusion of their adjacent collars (laterally the fusion producing a ligamentous connection) is evident. The looser fascial collar of the rectum is also mobilized (Curtis, A H., Anson, B. J., and Beaton, I. E.: *Surg , Gynec & Obst* , 1940)

RECTAL CAPSULE (FASCIA RECTALIS). Over that portion of the rectum covered by peritoneum the fascial capsule is usually indefinable. However, in its extraperitoneal portion the rectum has a well defined capsule which is formed by a splitting of the presacral hypogastric fascial wing into anterior and posterior layers to surround the rectum, particularly that of the ampullary region

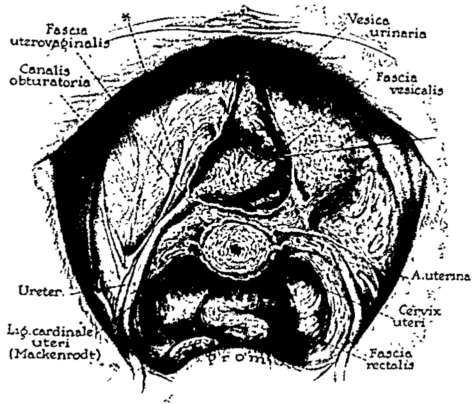


FIG. 126. The fascial collars on a higher plane. Broad ligament, basal structures. Ligamentous supports of bladder and uterus and fascial coats of pelvic organs. In the midportion of the pelvis, on the right the uterine vessels have been excised, the remainder of the cardinal ligament retained for comparison with the structures exposed by deeper dissection on the left. On the left side, the veins have been cut near their point of emergence from the uterine wall where they form a pedicle, elongated vertically. The ureter is shown in its surgically important relation to the uterine artery, and to the fused fascial sleeves of the bladder and vagina. The vesical artery has been retained. In the anterior part of the pelvic cavity on the right side the fascial covering of the bladder has been partially stripped away, leaving the muscular coat exposed on the superior surface. On the left side, the vesical layer of the endopelvic fascia has been freed, and that part of the bladder has been drawn toward the right in order to demonstrate the continuity of the diaphragmatic fascia and the vesical fascia. The fascia of the pelvic diaphragm is now clearly revealed, together with its upward-directed vesical and uterine collars. (Curtis, A. H., Anson, B. J., and McVay, C. B.: *Surg., Gynec. & Obst.*, 1939.)

(fig. 124). The presacral wing fuses into the superior hemorrhoidal sheath containing the superior hemorrhoidal vessels and nerves and the important lymphatic glands of Gerota. Between the presacral wing and the parietal pelvic fascia over the anterior surface of the sacrum is the retrorectal space.

Caudally as the rectum curves anteriorly over the anococcygeal raphe (levator plate) the presacral wing comes to lie lateral to the rectal wall and forms a narrow fascial wing (caudal rectal septum of Peham and Amreich) which attaches to the fascia endopelvina. This septum separates the retrorectal and pararectal spaces.

The rectal capsule anteriorly separates the rectal musculature from the posterior layer of the rectogenital septum in the male and the rectovaginal septum in the female.

In the retrorectal space the condensations of fascia extending from the parietal fascia of the sacrum to the rectal capsule are commonly referred to as the rectal stalks or shelves (stalks of Jonesco).

Subserous Fascia (Subperitoneal Fascia; Tela Subserosa, Etc.)

The terminology of this fascia is somewhat confusing. The term subserous has been broadly used to include all the fascia below the peritoneum regardless of its gross character or function. However the term as used here will be limited to that areolar fascia or loose connective tissue irregularly distributed and ubiquitously interspersed between the viscera, their fascial capsules, the perivascular sheaths, and their fascial wings.

The vesical portion of this fascia is poorly defined over the dome of the bladder but at its superolateral margin it fuses with the superior hypogastric wing (lateral false ligament of the bladder) and is definable as a separate layer. At the diaphragmatic level it fills in the space of Retzius and forms the retropubic fat pad.

Over the uterine body this layer is scarcely definable. At the cervical level it fills in the interval between the layers of the broad ligament, the parovarium and parametrium and the mesen-

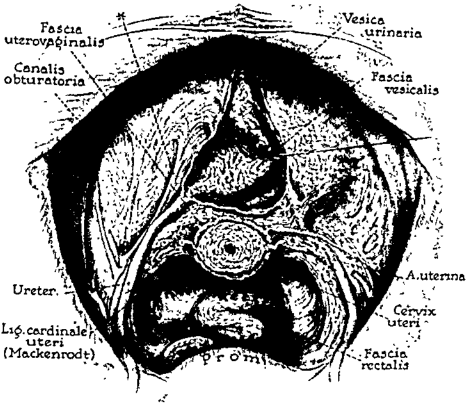


FIG. 126. The fascial collars on a higher plane. Broad ligament, basal structures. Ligamentous supports of bladder and uterus and fascial coats of pelvic organs In the midportion of the pelvis, on the right the uterine vessels have been excised, the remainder of the cardinal ligament retained for comparison with the structures exposed by deeper dissection on the left. On the left side, the veins have been cut near their point of emergence from the uterine wall where they form a pedicle, elongated vertically. The ureter is shown in its surgically important relation to the uterine artery, and to the fused fascial sleeves of the bladder and vagina. The vesical artery has been retained. In the anterior part of the pelvic cavity on the right side the fascial covering of the bladder has been partially stripped away, leaving the muscular coat exposed on the superior surface. On the left side, the vesical layer of the endopelvic fascia has been freed, and that part of the bladder has been drawn toward the right in order to demonstrate the continuity of the diaphragmatic fascia and the vesical fascia. The fascia of the pelvic diaphragm is now clearly revealed, together with its upward-directed vesical and uterine collars. (Curtis, A. H., Anson, B. J., and McVay, C. B.: *Surg., Gynec. & Obst.*, 1939.)

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tery of the vas deferens in the male. Laterally, it fuses into the important cardinal ligament (Mackenrodt) of the uterus.

The rectal portion consists primarily of areolar tissue intermingled in the fascia propria (presacral wing) surrounding the rectum posteriorly. Anteriorly, below the peritoneum in the male, it fills in the rectovesical pouch.

In general this fascia may be considered the "filler-in" connective tissue in and between the named structures of the pelvic fascia without distinction as to parietal or visceral layers. It is generally continuous throughout with the endogastric fascial plane of the abdomen.

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the perineum, anal canal and rectum should be considered as a loose system in which free anastomoses and overlapping, not only within itself, but also with adjacent viscera, seem always possible. In the present state of our knowledge the various groups are not clearly defined.

The Anorectal Lymphatics

The anorectal lymphatics may be conveniently divided into three groups which have been farily well established by the extensive work of Cunéo, Sappey, Poirer, Delamérs, Quénu and others. They are as follows:

- Perineal group
- Anorectal group:
  - Anal portion,
  - Rectal portion
    - Intramural system
    - Extramural system

Perineal Group

The perineal group or cutaneous system is also described as the inferior group. It drains both the superficial and deep layers of the perineal skin. The afferent collecting trunks follow, in general, the perineoscrotal or labial folds and terminate in the inferolateral group of inguinal nodes. The exact drainage group, however, seems to vary. In 28 cases, Gerota has seen the cutaneous lymphatics of the anus end in the supero-internal group 15 times, in the inferolateral group 8 times. In 4 cases they ended in these groups combined and once each in the supero-internal, infero-internal and infero-external groups (figs. 127 and 128).

Although the cutaneous system is described as apparently a fairly separate plexus, there is probably considerable overlapping and anastomosis between the perineal and rectal intramural groups, particularly the plexuses which lie in the anoderm of the anal canal and the submucosa of the perineal rectum. Nesselrod,

CHAPTER VIII

The Perineo-Pelvic Lymphatics

General Considerations

The anorectal region is a sharply differentiated portion of the intestinal tract, richly supplied with lymphatics which are very *difficult to demonstrate and are not yet clearly defined.*

In its intrapelvic position the rectum loses most of its peritoneal reflections. Its anterolateral surfaces retain their peritoneal reflected folds of Douglas, but below and posteriorly it is entirely devoid of peritoneum. The loss of peritoneum abruptly modifies the lymphatic drainage. the important subserous lymphatic system throughout the intestinal tract above is now replaced by the rectal lymph sinus immediately surrounding the rectum.

Furthermore, extraperitoneally the rectum comes into intimate relation with the various planes of the complex pelvic visceral fascia. The neurovascular sheaths, the more important components of the visceral pelvic fascia, are of particular significance in rectal and sigmoidal lymphatic drainage.

Finally the rectosigmoidal, anorectal and anocutaneous junctions are embryologically and anatomically transitional areas in respect to their muscular, their nerve and particularly their vascular supply. *Therefore, they present certain peculiarities of* the lymphatics which require special description. These anatomic considerations are most important in the pathologic concept of the extensions of cancer, suppurative processes and their surgical management.

From the practical and clinical standpoint the lymphatics of

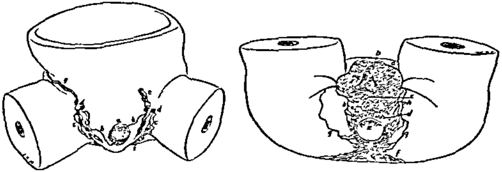


FIG. 128. Lymphatic system. Left: Lymphatics of the skin of the shaft of the penis (anterior view) in the same specimen as that represented in fig. 127. Injection made in the skin of the shaft, using mercury. *a*, network of the skin of the shaft of the penis; *b*, *b*, collecting vessels from the network of the shaft; *c*, *c*, collecting vessels from the perianal network; *d*, *d*, inguinal nodes; *e*, beginning of the external iliac chain of the collecting vessels; *f*, network of the perianal skin; *g*, collecting vessels from the superior gluteal region. Right: Perianal lymphatics and lymphatics of the external genitalia of a colored female fetus at term, viewed from below: The anus was dilated before fixation. Injections made in the skin overlying the lumbar, gluteal, and sacrococcygeal regions, in the anal skin, in the skin of the fourchet, and in the skin of the base of the right labium majus, using mercury. *a*, superficial lymphatic network of the labium majus; *b*, superficial network of the labium minus; *c*, superficial network of the fourchet; *d*, perianal network; *e*, anal network showing the origin of the vessels which ascend in the rectal columns of Morgagni; *f*, sacrococcygeal network; *g*, *g*, collecting vessels from the postanal plexus (sacrococcygeal); *h*, *h*, collecting trunks from the perianal and anal networks (Nesselrod, J. P.: *Ann. Surg.*, 1936.)

and complicating strangulated internal hemorrhoids is significant in this regard.

The skin overlying the coccyx and lower sacrum contains an extensive plexus which communicates with the perineal plexus and the adjacent lumbar and gluteal plexuses. These may drain directly into the inguinal nodes or, as pointed out by Nesselrod, by way of the afferents along the iliac crest (fig. 129).

Anorectal Group

ANAL PORTION. The anorectal line or subjacent pecten has often been described and referred to as the dividing line between the visceral and somatic lymphatics. Clinical observation would tend to disprove this oft-repeated statement as somewhat misleading.

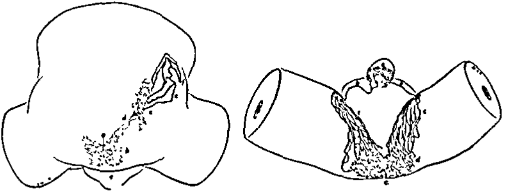


FIG 127. Lymphatic system. Left: Perianal and gluteal lymphatics (posterior view) of a white male fetus at term: Injections made along the anal margin and in the skin over the gluteal region, using mercury. *a*, anus; *b*, network of the perianal skin; *c*, plexus of skin over the gluteal region; *d*, anastomotic vessels; *e*, collecting vessels; *f*, collecting vessels from the superior gluteal region passing to the groin; *g*, scrotum. Right: Penile and perianal lymphatics, viewed from below, in the same specimen: Injections made in the skin on the shaft, using mercury. *a*, network of the skin of the shaft of the penis; *b*, *b*, collecting vessels from the network of the shaft; *c*, *c*, collecting vessels from the perianal network; *d*, network of the perianal skin; *e*, anus. (Nesselrod, J. P : *Ann. Surg.*, 1936.)

in his commendable study of the pelvic lymphatics, states that "there are definite anastomoses between the lymphatic plexuses of origin of the anal canal with those of the rectum" (fig. 128).

In this regard it may be emphasized that the anal columns and the papillae when present represent the terminal interdigitations of the ectoderm and should theoretically, therefore, drain to the inguinal lymphatic nodes.

The internal sphincter muscle with its mucosal and submucosal structures is partly encircled by the upper portions of the external sphincter muscle, and the fibro-elastic extensions of the conjoined longitudinal muscle of the rectum distribute themselves not only to the muscles and anal canal lining (anoderm) but also to the perianal skin. This arrangement presents an intricate overlapping of the lymphatics which tends to increase the difficulties in tracing the true anatomic course of a single plexus. The fact that the lymph flow in these plexuses may be reversible further complicates the problem. The perianal edema following hemorrhoidectomy

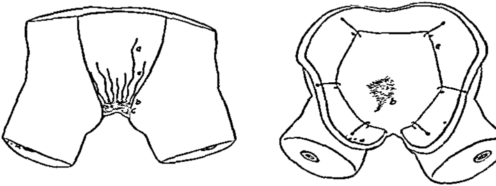


FIG. 130. Lymphatic system. Left: Coronal section of the rectum, showing the anterior view of the posterior half of a colored male fetus at term: Injection made in the skin of the anal canal, using mercury. *a*, *a*, lymphatic vessels lying in the columns of Morgagni; *b*, level of the anorectal line; *c*, network of the skin of the anal canal. Right: Lymphatics of the rectal mucous membrane (anterior view) of a colored female fetus at term: Injection made in the rectal mucous membrane, using Gerota's solution. *a*, rectum laid open; *b*, network of the rectal mucous membrane in the region of the upper portion of the ampulla. (Nesselrod, J. P.: *Ann. Surg.*, 1936.)

divisable into intramural (intraparietal) and extramural (extraparietal) groups.

Intramural System. The intramural lymphatic plexuses of the rectum ramify in the mucosa, submucosa and musculature of the bowel and drain into an extensive extramural system of fairly well defined channels or pedicles with interpolated and terminal nodal groups—the so-called zones of spread.

As originally described by Gerota, and confirmed by Poirer and his co-workers as well as by Oliveira and others, the rectum has two fairly distinct zones of origin of the intramural lymphatics, a lower and upper, divided roughly by the middle rectal valve of Kohlrausch. This valve also marks separate lower and upper zones of lymphatic spread from the rectum to the 3 extramural pedicles, the lower zone of origin being drained by all three lymphatic pedicles—superior, middle and anterior—while the upper zone of origin is drained only by the superior pedicle. This distinction in lymphatic drainage is highly significant to the spread of recto-

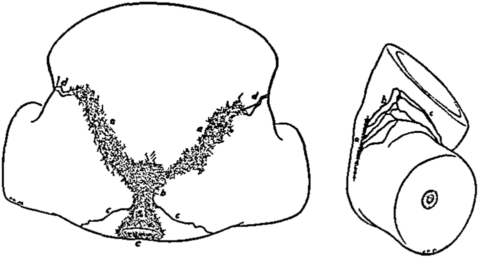


FIG. 129. Lymphatic system. Left: Anal and perianal lymphatics and the lymphatics of the skin overlying the sacrococcygeal and superior gluteal regions (posterior view) in the same specimen shown in fig. 128, right. *a*, *a*, plexuses of the skin of the superior gluteal region; *b*, plexus of the skin overlying the sacrococcygeal region; *c*, *c*, collecting vessels from the sacrococcygeal plexus which pass to the groin; *d*, *d*, collecting vessels from the superior gluteal networks passing *to the groin on either side by way of the superior route, following the curve of the* iliac crest; *e*, anal network, showing the origin of the vessels which ascend in the rectal columns of Morgagni. Right: Lymphatics of the skin of the superior gluteal region (lateral view) in the same specimen: Injections made in the skin over the gluteal region, using mercury. *a*, Network of the skin over the superior gluteal region; *b*, collecting vessels; *c*, collecting trunks passing to the groin by way of the superior route, following the curve of the iliac crest. (Nesselrod, J. P.: *Ann. Surg.*, *1936.*)

Three plexuses of the anal canal and the sphincteric portion of the rectum are usually demonstrable: the mucosal, submucosal and intramuscular plexuses. The mucosal and submucosal sets are continuous with those of the rectum proper and extend through the anal canal to anastomose with the perineal plexuses draining to the inguinal nodes as previously mentioned. The submucosal ramifications are particularly rich in the columns of Morgagni and there are probably both afferent and efferent channels from these important zones (fig. 130).

RECTAL PORTION. *The lymphatics of the rectum proper are*

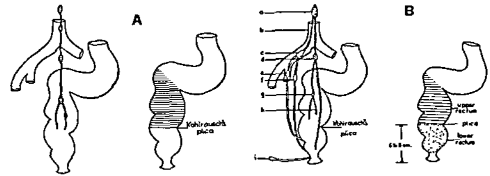


FIG 131. A· Injection of a blue dye above the plica of Kohlrausch; the lymphatic network of the upper rectum is colored by the dye, and the lymphatics accompanying the superior hemorrhoidal vessels are the only ones to become colored by the dye. (Modified from Villemin, Huard, and Montagné: *Rev. chir.*, *63:* 39, 1925. In Sauer and Bacon· *Am. J. Surg.*, *81:* 111, 1951.) B: A yellow dye was injected into the rectum below the plica; and a blue one, above. It is shown that the rectum possesses 2 distinct networks of origin, and that the plica is the limit between them. The inferior and the lateral trunks drain only the lower rectum, while the superior pedicle drains the upper and the lower rectum; *a*, aortic nodes; *b*, aorta; *c*, iliac nodes; *d*, rectosigmoid nodes; *e*, hypogastric nodes; *f*, sacral nodes; *g*, *h*, anorectal nodes; *i*, inguinal nodes. (Modified from Villemin, Huard, and Montagné· *Rev. chir.*, *63:* 39, 1925. In Sauer and Bacon: *Am. J. Surg.*, *81:* 111, 1951.) (Sauer and Bacon: *Surg., Gynec. & Obst.*, *95:* 2, 1952.)

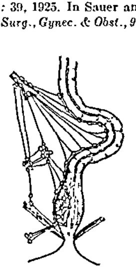


FIG. 132. The extrarectal lymphatics. Schematic representation of the extramural lymphatic system of the rectum and pelvic colon. The efferents pass in three directions: downward through the ischiorectal fossa, laterally between the levatores ani and the pelvic fascia, and upward in the pelvic mesocolon. (Miles, W. E.· *Cancer of the Rectum*. Harrison & Sons, Ltd., 1926.)

sigmoidal cancer and its surgical management. Although the spread is usually upwards along the branches of the superior hemorrhoidal vessels, the lateral spread through the lateral or middle hemorrhoidal stalk is common in low rectal cancer in the region of the middle rectal valve (fig. 131).

Extramural System. The extramural lymphatics of the rectum despite some overlapping may be divided into superior, middle (lateral) and inferior pedicles or zones of spread (fig. 132).

a) The superior pedicle, the most important, drains roughly the upper rectum, sigmoid and lower portion of the colon. Its main channels and nodes follow the course of the superior hemorrhoidal vessels throughout the mesorectum.

The first group of discrete nodes in the mesorectum are the glands of Gerota. As the mesorectum blends into the mesosigmoid several groups of nodes have been described, notably by Villemin and his co-workers. These groups are usually found near the bifurcation of the superior hemorrhoidal and inferior mesenteric vessels. They are considerably variable but three more or less distinct groups of nodes have been described. The first and important group is located at the bifurcation of the superior hemorrhoidal artery. Into this group drain the main portion of the afferent channels from the upper rectum and they are hence the most important group in the upward zone of spread.

The second group is distributed around the junctions of the superior hemorrhoidal and sigmoidal vessels. They also drain the upper rectum and the lower sigmoid.

The third Group is located at the junction of the inferior mesenteric and left colic vessels. It is commonly referred to as the rectosigmoidocolic group inasmuch as it can receive direct drainage from any one of these portions of the bowel—a significant fact in cancer metastases. Ault and others have emphasized that complete eradication of the rectosigmoidocolic nodes with high ligation of the inferior mesenteric pedicle favors the prognosis in rectosigmoidal cancer (fig. 133).

b) The middle or lateral pedicle or zone of spread of the extra-

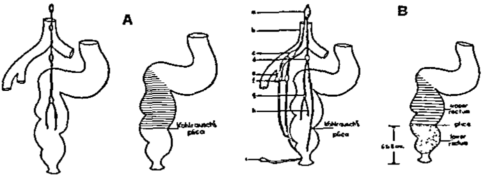


FIG. 131. A: Injection of a blue dye above the plica of Kohlrausch; the lymphatic network of the upper rectum is colored by the dye, and the lymphatics accompanying the superior hemorrhoidal vessels are the only ones to become colored by the dye. (Modified from Villemin, Huard, and Montagné: *Rev. chir.*, *63:* 39, 1925. In Sauer and Bacon: *Am. J. Surg.*, *81:* 111, 1951.) B: A yellow dye was injected into the rectum below the plica; and a blue one, above. It is shown that the rectum possesses 2 distinct networks of origin, and that the plica is the limit between them. The inferior and the lateral trunks drain only the lower rectum, while the superior pedicle drains the upper and the lower rectum; *a*, aortic nodes; *b*, aorta; *c*, iliac nodes; *d*, rectosigmoid nodes; *e*, hypogastric nodes; *f*, sacral nodes; *g*, *h*, anorectal nodes; *i*, inguinal nodes. (Modified from Villemin, Huard, and Montagné: *Rev. chir.*, *63:* 39, 1925. In Sauer and Bacon: *Am. J. Surg.*, *81:* 111, 1951.) (Sauer and Bacon: *Surg., Gynec. & Obst.*, *95:* 2, 1952.)

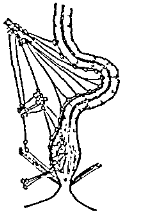


FIG. 132. The extrarectal lymphatics. Schematic representation of the extramural lymphatic system of the rectum and pelvic colon. The efferents pass in three directions: downward through the ischiorectal fossa, laterally between the levatores ani and the pelvic fascia, and upward in the pelvic mesocolon. (Miles, W. E.: *Cancer of the Rectum.* Harrison & Sons, Ltd., 1926.)

rectal lymphatics lies subperitoneal and ramifies throughout the complex visceral endopelvic fascia, following in general the neurovascular sheaths of the main vessels. The important nodal groups usually lie in close relation to the vascular bifurcations. Cunéo has described three main pedicles or divisions of the middle or lateral zone of spread—anterior, lateral and posterior (fig. 134).

1. The anterior pedicle, according to Reinhold, is a minor but important pedicle on either side of the rectum which extends between the layers of the rectogenital septum and along the lateral margins of the prostate, seminal vesicles, or vagina and usually drains into the internal iliac nodes and occasionally into the ex-

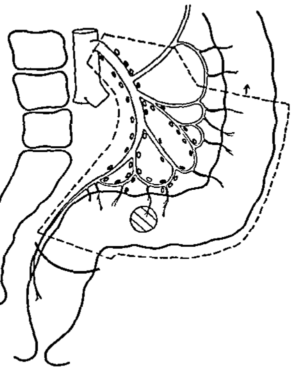


FIG. 133. Carcinoma of the lower sigmoid. This drawing illustrates what may be considered an adequate removal of the cephalad zone of lymphatic spread along the inferior mesenteric vessels. The site of division of the upper sigmoid may be moved in a cephalad direction, as indicated by the arrow, so that descending colon or even left transverse colon may be brought down for an anastomosis. (Ault et al.: *Surg., Gynec. & Obst.*, *94:* 2, 1951.)

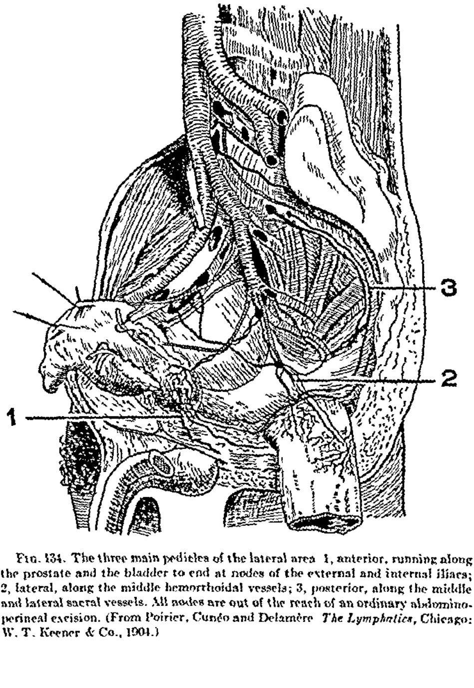


FIG. 134. The three main pedicles of the lateral area 1, anterior, running along the prostate and the bladder to end at nodes of the external and internal iliacs; 2, lateral, along the middle hemorrhoidal vessels; 3, posterior, along the middle and lateral sacral vessels. All nodes are out of the reach of an ordinary abdomino-perineal excision. (From Poirier, Cunéo and Delamère *The Lymphatics*, Chicago: W. T. Keener & Co., 1904.)

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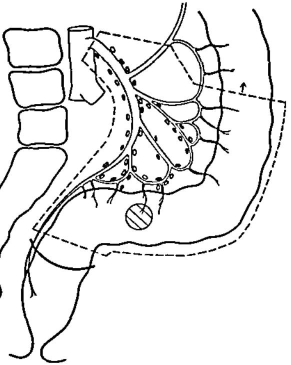


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either side of the rectum on the upper surface of the levators, terminating in nodes lateral to the sacral promontory.

Furthermore the lymphatic drainage of the uterus and its adnexa commonly fuses into the rectal pedicles extending through the root of the hypogastric sheath to reach the important concealed hypogastric group of nodes posterolateral to the hypogastric veins and its branches (fig. 135).

Surgicopathologic Considerations

The surgery and prognosis of rectal cancer depend primarily on the involvement of the extrarectal lymphatics and veins. Dukes, in his commendable detailed pathologic study of 1000 cases of rectal cancer, has presented fundamental observations of practical clinical and surgical application. The more important of these include the following: the fact that in "cases without glandular metastases the results of surgical treatment were the same whatever the situation of the growth, but for cases with glandular metastases the results varied with the position of the growth in the rectum." The significance of the location of the growth relative to the middle rectal valve may be re-emphasized. This explains the sometimes unexpected long survival of the poor-risk patient following perineal excision with a high rectal cancer. As Dukes interjects, such pleasant surprises help us "to walk cheerfully through the world."

With lymphatic metastases he believes that figures will show that "the worst place to have rectal cancer is the ampulla." This is significant to the "pull through" and sphincter preservation types of surgery.

Significant also to the surgery is the fact that the size and area of rectal wall involved bear no constant relation to the extent or location of the metastases. Venous metastasis occurs in about 17 per cent of the cases and likewise bears no relation to the size of the tumor but rather to its rapidity of growth which usually indicates a high grade of malignancy (fig. 136).

ternal group, anastomosing with the middle hemorrhoidal or lateral sacral channels.

2. The lateral pedicle of the lateral zone of spread, the most important of the extramural group, courses mainly through the lateral ligament of the rectum following the middle hemorrhoidal stalk and drains into the obturator or important hypogastric nodes (Cunéo and Marcille). *Recent observations* by *Dukes, Wood and* Wilbur, Bacon and Sauer, and others have established the fact that the neglected lateral spread of rectal cancer is through the *fascia of the lateral ligament to the higher pelvic nodes rather* than through the fascia overlying the levator ani muscle or the muscle itself as originally described by Miles. The lateral lymphatic drainage pattern has assumed increasing significance in the surgical approach to low rectal cancer as well as that of the uterus and its adnexa.

3. The posterior pedicle consists mainly of channels which extend along the middle and lateral sacral vessels. The former drain into the nodes located near the sacral promontory, the latter into nodes near the bifurcation of the common iliac and the hypogastric vessels.

c) The inferior or downward zone of spread: the lymphatics of this pedicle drain the terminal rectum and have been described under the anal subdivision of the anorectal group (p. 255).

The majority of the lymphatics from the rectal lymph sinus above the middle rectal valve either pass through or drain into nodes contained in the superior zone, and it is therefore the most important from the standpoint of cancer metastases. The genitourinary organs have a lymphatic distribution which is fairly distinct from that of the rectum and the two systems are usually simultaneously involved only by direct continuity in long-standing malignancy. Anteriorly in the male, however, efferent lymphatics of the rectal sinus may anastomose through the lymphatics of Denonvilliers' fascia with those of the prostate, seminal vesicles or base of the bladder or with those of the posterior prostatic or prerectal spaces. Efferent lymphatics may also pass posteriorly on



FIG 136. Photograph of hemorrhoidal vein thrombosed and distended with malignant growth. (After Dukes.)

The great variation in the number of lymphatic glands involved, their close relation to the grade of the primary tumor as well as their significance to the ultimate prognosis is emphasized. Patients with 5 or more glandular metastases rarely live more than 5 years.

Dukes has classified rectal cancer on the basis of lymphatic metastasis into A and B Cases, and C Cases with sub-groups 1

remains in its normal position. Injections made in the muscular layer of the posterior vaginal wall, in the muscular layer of the cervix, of the uterus, and of the fallopian tubes, and in the ovaries, using Gerota's solution. *a*, Rectum; *b*, vagina; *c*, posterior perivaginal lymphatic network; *d*, muscular network of the anterior wall of the rectum; *e*, collecting vessels from the vaginal network; *f*, lateral sacral nodes; *g*, uterine network; *h*, collecting vessel of the external iliac pedicle, from the uterine body and cervix; *i*, collecting vessel of the external iliac pedicle, from the vagina; *j*, external iliac nodes; *k*, network of the fallopian tube; *l*, collecting vessels from the fallopian tube entering into the abdominal or lumbar pedicle; *m*, ovarian collecting vessels entering into the abdominal pedicle; *n*, abdominal or lumbar pedicle; *o*, juxta-aortic nodes; *p*, *p*, kidneys. (Nesselrod, J. P.: *Ann. Surg.*, 1936.)

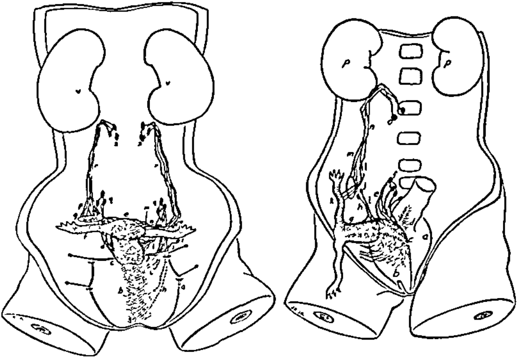


FIG. 135. Lymphatics of internal genitalia of a colored female fetus at term. Left: Anterior view: Injections made in the mucous membrane of the vagina, posterior wall, in the muscular layer of the posterior lip of the cervix, in the muscular layer of the uterus and of the fallopian tubes, and in the ovaries, using Gerota's solution. *a*, vagina laid open to show the posterior wall; *b*, vaginal network, *c*, cervical network; *d*, network of the uterine body; *e*, network of the uterine fundus; *f*, network of the fallopian tube; *g*, network of the ovary; *h*, collecting vessels from the inferior portion of the vagina; *i*, collecting vessels from the superior portion of the vagina; *j*, collecting vessels from the vagina passing to a hypogastric node *t*, *k*, cervical collecting vessel which joins vessels *h* and *i* to form the lateral sacral pedicle of the vagina passing to the lateral sacral nodes at *q*; *l*, cervical and uterine collecting vessels which make up the lateral sacral pedicle of the cervix passing to the lateral sacral nodes at *q*; *m*, cervical collecting vessel which passes upward to join the abdominal pedicle of the uterus; *n*, collecting vessels from the uterine fundus and from the upper portion of the uterine body entering into the abdominal or lumbar pedicle *r*; *o*, collecting vessels from the fallopian tube entering into the abdominal pedicle *r*; *q*, *q*, lateral sacral nodes; *r*, *r*, abdominal or lumbar pedicles; *s*, *s*, juxta-aortic nodes; *t*, hypogastric node; *u*, lateral sacral pedicle of the vagina; *v*, *v*, kidneys. Right: Anterolateral view: The left broad ligament was sectioned near its lateral attachment, allowing the uterus to be partially rotated and displaced to the right. Thus the observer obtains a posterior view of the uterus and a posterolateral view of the vagina. The rectum

is commonly enough mistaken and operated on for chronic fissure in ano or hemorrhoids. We have had on our service at the New York Cancer Hospital 4 cases of anal epithelioma unsuspectingly operated on for fissure, in which preliminary colostomy, wide excision of the rectum and radiation to the inguinal nodes were futile.

The anal group of the intramural lymphatics is of particular interest in infectious processes of the perianal region, which comprise the majority of conditions amenable to treatment. The precise pathways by which these processes, particularly the tuberculous, extend to the adjacent tissues is still not yet definitely settled. The large and important subject of fistula is also directly related to this problem.

Infectious processes which reach the pecten zone of the anal canal may follow lymphatics which reach the ischiorectal fossae, the perianal or supralevator spaces. It is a clinical fact not readily explained that the largest ischiorectal abscesses are not usually preceded by symptoms referable to the anal canal or rectum until the abscess is well established. Furthermore, in gonorrhea and tuberculosis of the anal canal or rectum, secondary abscess formations are fairly constantly found in the perianal spaces—not in the ischiorectal space, the infection having gravitated presumably through the lymphatics or tissue spaces directly below the squamous lining of the anal canal (anoderm).

The anal group of lymphatics is also of significance in extensions of perianal infections from the labia, Bartholin's and Cowper's glands, the urethra and the vagina.

McMaster, in his fundamental investigations, has emphasized the abundance of the cutaneous lymphatics and the rapidity of transport through them, which is much more rapid than usually considered. He likewise has demonstrated enormous changes in the permeability of the lymphatics following local injury as well as in common systemic diseases involving fluid exchange.

These observations are significant to the entire subject of anorectal lymphatic drainage in cancer, hemorrhoids, fistula,

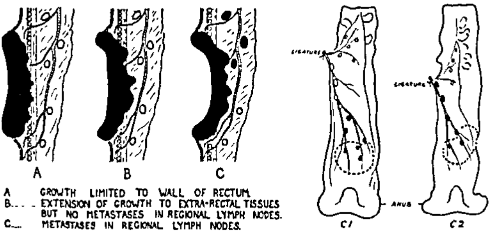


FIG. 137. Classification of rectal cancer. (After Dukes.) A, growth limited to wall of rectum; B, extension of growth to extra-rectal tissues, but no metastases in regional lymph nodes; C, metastases in regional lymph nodes. In cases labelled C 1 metastases are present in some of the lymphatic glands but the uppermost hemorrhoidal glands are still free. In C 2 cases the lymphatic spread has extended up to and including the gland immediately below the ligature.

and 2 (fig. 137). Although the classification is primarily pathological, it is of great value in assessing prognosis and in the evaluation of the various surgical procedures relative to the site and spread of the tumor.

Clinically, sharply defined limitations of lymphatic spread in the anorectal region are not possible, and although fairly circumscribed locations are drained theoretically by a certain lymphatic group, aberrant and unsuspected extensions occur constantly with "leap-frogging" to remote nodes.

It may be noted in this regard that the exact intercommunication between the lymphatics, the arteriovenous and tissue-space systems is not yet definitely decided. For example, we have observed carcinomatous metastases to the skull from a low rectal *carcinoma*.

The common inguinal adenopathy in anal and perianal infections need scarcely be mentioned. However, it is important to emphasize here that metastases from anal epitheliomata reach the inguinal nodes comparatively early. This usually fatal condition

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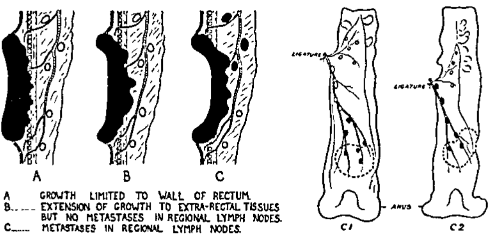


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These observations are significant to the entire subject of anorectal lymphatic drainage in cancer, hemorrhoids, fistula,

fissure, "pectenosis," lymphopathia venereum and the various anorectal infectious processes. It is also of clinical importance in the patholysis as well as the surgery of these conditions.

The rectal lymphatics are of some significance in the extensions of infections from the genito-urinary organs to the perirectal spaces. Although the lymphatic plexuses of these adjacent systems do not overlap to any appreciable extent, infections from one system to the other are fairly common. The urologists are quite convinced that foci in the prostate, deep urethra and vesicles may produce secondary abscesses in the supralevator as well as in the ischiorectal spaces, and the marked relative increased incidence of these abscesses in the male sex has been explained on this basis. In the female, supralevator and ischiorectal abscesses are comparatively less frequent because the lymphatics from the vagina, tubes and ovaries (the homologues of the prostate, vesicles and testes in the male) drain to the pelvic, periuterine or lateral sacral zones with abscess formation in the cul-de-sac rather than in the supralevator or ischiorectal spaces.

The extramural lymphatics of the sigmoid follow in general the vessels in the meso and drain into the inferior mesenteric or lumbar nodes.

Lymphatics of the Colon

The lymphatics of the colon consist essentially of submucous and subserous plexuses which communicate freely through the muscular tunics. The main regional nodes varying in size and position are scattered along the course of the main blood vessels and are named accordingly: inferior mesenteric, left and middle colic, ileocolic nodes, etc.

Summary

I. Anus and anal canal
  Inguinal group-usually inferior

II. Rectum
   1. Above middle valve (Plica of Kohlrausch)—by superior pedicle to hypogastric, iliac, lateral lumbar or superior mesenteric nodes
   2. Below middle valve—by inferior pedicles to anorectal, inguinal, or sacral nodes; by lateral pedicle to external iliac, hypogastric or obturator nodes

III. Vagina
   1. Superior or external iliac
   2. Middle or hypogastric
   3. Inferior
      - lateral sacral
      - pedicle of sacral promontory

IV. Cervix
   1. Anterior or external iliac
   2. Middle or hypogastric
   3. Posterior
      - lateral sacral
      - dicle of sacral promontory

V. Uterus
   1. Lumbar
   2. External iliac
   3. Lateral sacral
   4. Inguinal

VI. Prostate
   1. Anterior or external iliac
   2. Middle or hypogastric
   3. Posterior
      - lateral sacral
      - pedicle of sacral promontory

VII. Bladder
   Same as prostate—usually to external iliac group

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CHAPTER IX

Nerve Supply to the Colon, Rectum and Anal Canal

Direct or reflex sensorimotor disturbances arising in the genito-urinary and gastro-intestinal tracts constitute a large part of the symptomatology encountered by general practitioners and the specialists, including the proctologist. The proper evaluation of these symptoms, which freqently enough arise in one visceral system to be remotely and unsuspectingly referred to another, demands at times the greatest diagnostic acumen. The proper interpretation of such symptoms depends on a comprehensive understanding of the neural pathways involved.

From the surgical viewpoint a number of autonomic dysfunctions, particularly of the pelvic viscera, have responded favorably to interruption of the pelvic plexus (Frankenhauser's plexus). These include severe dysmenorrhea, pain arising in the bladder, uterus or rectum, Hunner's ulcer; proctalgia fugax; adynamic ileus and occasionally chronic non-specific ulcerative colitis.

From the etiologic standpoint a diminution or commonly a total absence of the parasympathetic fibers and their terminal ganglia in the colon or urinary bladder has accounted for megacolon, megalobladder, megaloureter and severe constipation, especially in children.

General Anatomic Considerations

The entire nervous system is commonly divided into:

The somatic or cerebrospinal system which is:

Motor to skeletal muscle
Sensory from joints, skin and scalp
Autonomic System which is divided into three major subgroups:
The midbrain or medullary group (craniobulbar)
The thoracolumbar group
The sacral group

Group 2 in this latter subdivision is the sympathetic system, while groups 1 and 3 are jointly referred to as the parasympathetic system, largely on account of its antagonistic action to the sympathetic group.

The sympathetic subdivision is formed mainly from cells of origin in the lateral horns of the gray matter of the spinal cord, from the 1st thoracic to the 3rd lumbar segments. The axones of these cells are the preganglionic fibers which usually terminate and synapse with the ganglionic cells in the sympathetic chain. However, they may pass unaltered to outlying ganglia or plexuses or continue, as many of them do, to the adrenal gland. The postganglionic fibers arise from a fresh synapse from either the sympathetic chain or more commonly from the larger irregular prevertebral plexuses e.g., the celiac, aorticorenal, superior and inferior mesenteric plexuses of the thoracolumbar outflow.

The sympathetic chain and the prevertebral plexuses form the main pathways or synapses for the sympathetic system in the abdomen.

The parasympathetic supply in the abdomen is mainly through the vagus

The cranial parasympathetic subdivision arises mainly from the cells of origin in the hypothalamus, midbrain or medulla. Preganglionic fibers from these cells of origin innervate the posterior pituitary, eyes, and glands of the head and neck. However, the bulk of these preganglionic fibers traverse the vagus nerve and are distributed to the thoracic and abdominal viscera.

The sacral parasympathetic subdivision arises mainly from cells of origin in the lumbar cord and they emerge in the anterior roots

of the 2nd, 3rd and 4th sacral nerves. Axones from these cells form the preganglionic fibers to the pelvic plexus.

Physiology

The sympathetics, in general, stimulate smooth muscle, causing vasoconstriction. They are also glandulomotor to the superficial and deep glands. In the alimentary tract they cause contraction of the sphincters and inhibition of the sigmoid colon and rectum. In the urinary bladder they contract the sphincters and inhibit its detrusor musculature.

The parasympathetics cause vasodilatation, are secretomotor to the glands, motor to the musculature of the intestinal tract and inhibitory to the cardiac, pyloric and ileocolic sphincters largely through the vagus nerve. Afferent fibers convey visceral sensibility from the alimentary canal to the ganglion nodosum of the vagus. The sacral outflow of the parasympathetics supplies motor fibers to the musculature of the distal colon and rectum, the rectosigmoidal junction and possibly inhibitory fibers to the internal anal sphincter. It also conveys motor fibers to the urinary bladder and inhibitory fibers to its internal sphincter; motor fibers to the uterine muscle, the seminal vesicles, prostate and ejaculatory ducts and vasodilator fibers to the penis and clitoris.

Regarding the innervation of the urinary bladder it may be noted here that McCrae and Kimmel have described an accessory set of nerve fibers which arise from the second, third and fourth sacral roots and reach the bladder in conjunction with the veins and vessels on the lateral wall of the pelvis, largely in the hypogastric sheath and its inferior hypogastric wing. These fibers enter the bladder with the ureter and its fascial investment. They completely circumvent the commonly described pathways, and apparently take over their sympathetic and parasympathetic functions when the latter are interrupted. This is significant to pelvic surgery.

The Sympathetic Arc

The afferent fibers arise primarily in the walls of the blood vessels and viscera. They reach the central nervous system by way of the white ramus communicans where they join the afferent fibers forming the posterior roots and end in the lateral horns of the cord. From the lateral horn the connector or intercalated *neuron gives rise to the preganglionic fibers which leave the cord* in the anterior spinal nerve roots, as the white rami communicantes, terminating in the lateral ganglia of the sympathetic trunk or in the outlying ganglionic plexuses (fig. 138).

It may be observed here that the white ramus communicans is the principal connection between the autonomic and cerebrospinal systems. Arising as it does from the lateral horns, its fibers are subject to the higher centers. Interruption of the white ramus destroys the sympathetic arc, separating the afferent sympathetic *neuron from its cell body in the posterior or lateral horns of the* spinal cord.

The Abdominal Autonomic System

The sympathetic portion of abdominal autonomic system is composed mainly of the sympathetic chain and the large prevertebral plexuses. This system has a parietal and visceral distribution: the former supplies the parieties of the skin, abdomen, blood vessels and glands, the latter supplies the abdominal viscera mainly through the large prevertebral plexuses, which may be conveniently divided into an upper and lower abdominal group (fig. 139)

The upper abdominal group consists essentially of the bilaterally connected celiac ganglion which derives its preganglionic fibers mainly from the greater and lesser splanchnic nerves arising from the sympathetic chain (thoracic v to xi). This large celiac plexus ramifies with the branches of the celiac arterial distribution and is also joined by branches from the right vagus; this is important from the point of reflex symptomatology. From the ganglion

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cells of the celiac plexus, fibers also arise which accompany the renal, adrenal superior mesenteric, internal spermatic and ovarian arteries contributing to the important plexuses of the same names. The reflex possibilities from such an extensive visceral sympathetic supply may readily be appreciated.

The proximal colon is supplied essentially from the superior mesenteric plexus, the fibers of which follow the branches and arcades of the terminal vessels and are finally distributed to the wall of the gut.

The lower abdominal group to the viscera consists mainly of

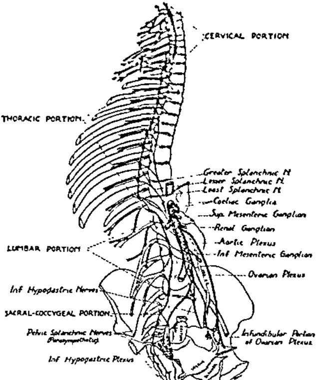


FIG. 139. Diagrammatic sketch to show the abdominal and pelvic sympathetic plexuses and their communications with the main sympathetic trunk as well as with the pelvic nerve. Spinal nerves, white; sympathetic nerves, black; parasympathetics, gray. (Labate, J. S.: *Surg., Gynec. & Obst.*, 1938.)

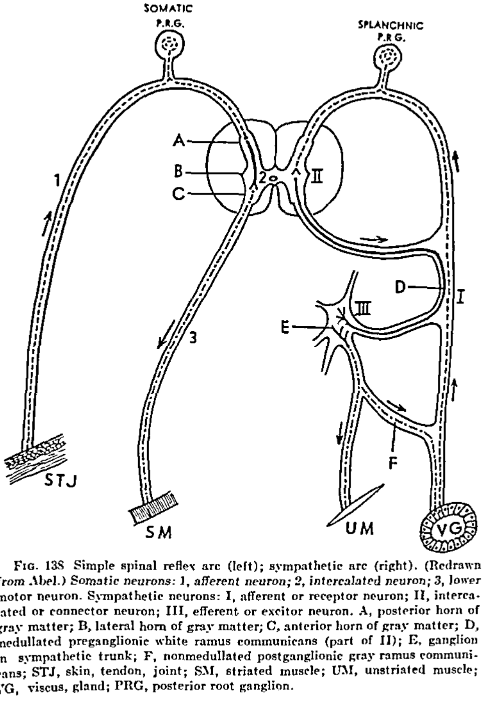


FIG. 138 Simple spinal reflex arc (left); sympathetic arc (right). (Redrawn from Abel.) *Somatic neurons: 1, afferent neuron; 2, intercalated neuron; 3,* lower motor neuron. Sympathetic neurons: I, afferent or receptor neuron; II, intercalated or connector neuron; III, efferent or excitor neuron. A, posterior horn of gray matter; B, lateral horn of gray matter; C, anterior horn of gray matter; D, medullated preganglionic white ramus communicans (part of II); E, ganglion in sympathetic trunk; F, nonmedullated postganglionic gray ramus communicans; STJ, skin, tendon, joint; SM, striated muscle; UM, unstriated muscle; VG, viscus, gland; PRG, posterior root ganglion.

medially directed postganglionic fibers from the lumbar ganglionated chain. These are the lumbar splanchnic nerves, or the lumbar sympathetic system, which form the intermesenteric, aortic and inferior mesenteric plexuses. The intermesenteric and aortic distributions of nerves are sometimes not considered as true plexuses. *Many fibers from the lumbar splanchnics, however,* ramify over the abdominal aorta. Nerves which also arise from the celiac plexus and extend downward on the lateral aspects of the aorta form the important intermesenteric nerves (fig. 140). These receive communicating branches from the lumbar splanchnics which are destined to supply the distal colon.

The extent to which the lumbar splanchnics mingle with the intermesenteric nerves is of some importance in the innervation of the distal colon and rectum. According to Abel, the distal colon receives no important contribution from the celiac plexuses or nerves but is innervated as noted above, by the lumbar splanchnics which contribute to the superior and inferior mesenteric plexuses. Surrounding the root of the inferior mesenteric artery, this latter plexus follows the distribution of the artery and, reaching the vascular arcades in the mesentery, it forms an anastomotic network, terminating finally in the walls of the colon.

The Abdominal Parasympathetic System

In the abdomen the source of the parasympathetic supply, particularly to the colon, is not well established.

According to Abel, it is not definitely known whether the parasympathetic innervation to the colon is derived wholly from the cranial division via the vagus or from the sacral outflow via the nervus erigens (fig. 141).

According to Lannon and Weller the parasympathetic innervation to the distal colon is comprised of from 3 to 6 fibers arising from the second and third sacral nerves. They are distributed direct to the descending colon and do not follow the vascular supply. Auerbach's plexus, the terminals of the parasympathetic

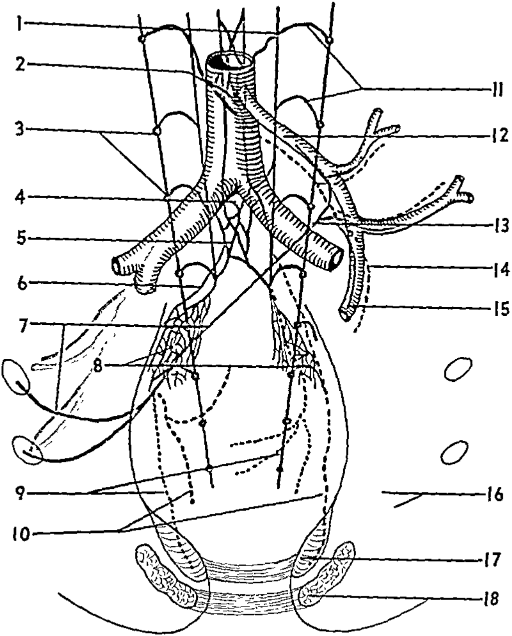


FIG. 140. The sympathetic nerve supply to the rectum. 1, intermesenteric nerves; 2, inferior mesenteric plexus; 3, ganglionated sympathetic chain; 4, interiliac triangle; 5, superior hypogastric plexus (presacral nerve); 6, inferior hypogastric nerves; 7, parasympathetic nerves (nervi erigentes) to rectum and sigmoid, 8, inferior hypogastric plexus (pelvic plexus); 9, efferent inhibitory fibers to rectal musculature and internal anal sphincter; 10, parasympathetic fibers terminating in the rectal wall; 11 lumbar splanchnic nerves (sympathetic supply to rectum and sigmoid through inferior mesenteric and superior hemorrhoidal branches); 12, inferior mesenteric artery; 13, parasympathetic supply to rectum and sigmoid; 14, a sympathetic supply to rectum by way of superior hemorrhoidal branches; 15, superior hemorrhoidal artery; 16, cerebrospinal somatic, motor, and sensory nerves to anal musculature; 17, internal anal sphincter; 18, external anal sphincter.

fibers, ramify into the extensive ganglionic plexuses of the bowel wall.

If extending direct to the colon they would not be involved in periarterial stripping for megacolon and this probably explains the poor results following this procedure—now almost entirely replaced by colonic resection to the level containing definite parasympathetic intramuscular ganglia.

The Pelvic Autonomic System

The sympathetic portion of the pelvic autonomic system is chiefly derived from the continuation of the inferior mesenteric plexuses and their lateral splanchnic connections to form the superior hypogastric plexus or presacral nerve.

Below the bifurcation of the aorta the superior hypogastric plexus divides into right and left hypogastric branches or plexuses and extending caudally on either side of the rectum they are joined by the sacral parasympathetic nerves (nervi erigentes). These two larger plexuses, which are also joined by sympathetic fibers from the pelvic ganglionated chain, form the large and important pelvic or inferior hypogastric plexus. The pelvic plexus conveys both preganglionic and postganglionic fibers (fig. 142).

The superior hypogastric plexus or pre-sacral nerve is of special proctologic, urologic and gynecologic interest, inasmuch as severe pelvic pain and other paresthesias may be relieved by its surgical exenteration. This plexus passes through the interiliac triangle and in this location is covered by peritoneum and partially embedded in the visceral pelvic fascia (fig. 143). It usually forms a definite plexus. However there are many variations. Labate in 75 dissections found a plexus in 84 per cent, a single nerve in 8 per cent and bilateral trunks in the remaining 8 per cent. Some fibers of this plexus may ramify posterior as well as anterior to the iliac vessels (fig. 144).

The parasympathetic portion of the pelvic autonomic system or the pelvic parasympathetic nerves (nervi erigentes) arise from

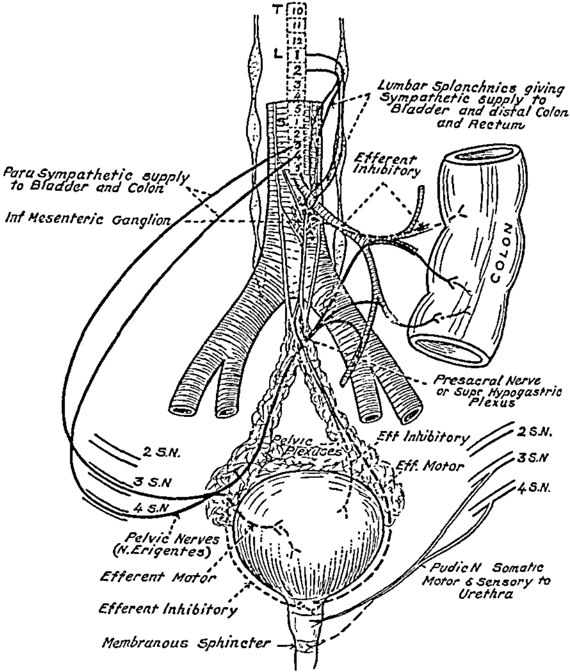


FIG. 141. Diagrammatic illustration of the parasympathetic nerve supply to the rectum. Note that the parasympathetic supplies efferent motor innervation to the detrusor musculature of the urinary bladder and inhibitory innervation to its internal sphincter, while the sympathetic supplies efferent inhibitory and efferent motor to the same structures. Practically the same reciprocal innervation supplies the rectum. (Abel, A. L.: *Surgery of the Sympathetic Nervous System.* Med. Publications, Ltd., 1938.)

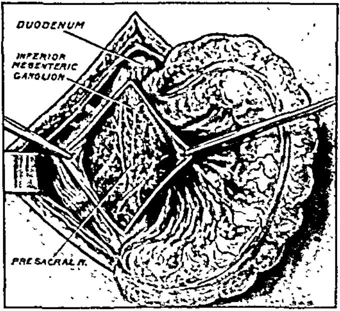


Fig. 143 Operative exposure of presacral nerve and inferior mesenteric ganglion. (Abel, A. L. *Surgery of the Sympathetic Nervous System*. Med. Publications, Ltd., 1936.)

predominant impulses. They also convey the more important pain impulses to higher centers.

In general the pelvic viscera receive their autonomic supply through the pelvic plexus and its subdivisions. These include the following sub-plexuses:

1. The hemorrhoidal plexuses in the region of the middle hemorrhoidal artery
2. The superior and inferior vesical plexuses which also supply the ureters and the urethra
3. The prostatic plexus
4. The ovarian plexus
5. Utero-vaginal plexus

Anson and Ashley have emphasized that the entire autonomic distribution in the pelvis forms a more or less distinct set of three neural sheets—superficial, intermediate and deep—which bear a

the second to the fourth sacral nerves. In front of the sacrum they contribute anastomotic fibers to the pelvic ganglion and continue to the pelvic plexus from which they reach their peripheral distribution to the pelvic viscera with their corresponding sympathetic branches. The inferior group of the parasympathetics from the pelvic plexus supply the rectal ampulla and anal canal (hemorrhoidal plexuses) (fig. 142).

The parasympathetics are considered of more importance in the sympathetic-parasympathetic relationship, and according to McCrae and McDonald they convey the stronger and functionally

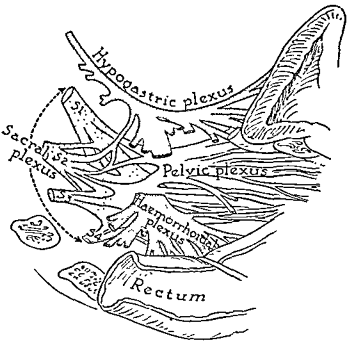


FIG. 142. Diagram of the pelvic plexus, showing origin and distribution of the chief components, and their gross interrelationships. Medial aspect. The hypogastric plexus is shown intact in its curving course to the urinary bladder, but has been cut away in that part which, overlying the pelvic plexus, contributes to the hemorrhoidal plexus. Between these two, and lateral to them, the fibers derived from the sacral nerves are shown streaming toward the bladder, prostate, anal canal, rectum, etc. (Ashley, F. L., and Anson, B. J.: *Surg., Gynec. & Obst.*, *82:* 598–608, 1946.)

and are distributed mainly to the upper rectum, dome of the bladder and the ductus deferens.

The intermediate or main neural sheet extends through the heavy or deep subperitoneal layers of the *visceral* fascia. Its main plexus is the large pelvic plexus with its continuations to the bladder, prostate and seminal vesicles mainly through the inferior hypogastric wing. Passing downward into this heavy layer are the rami of the inferior hypogastric plexus and passing upward into it are the parasympathetic rami from the sacral plexus.

The deep neural sheet composed of the sacral nerves lies deep to the *parietal* pelvic fascia (fig. 145).

Sympathetic Innervation of the Rectum and Anal Canal

The sympathetic innervation to the rectum and anal canal is mainly from three sources (fig. 140):

1. Sympathetic fibers from the inferior mesenteric plexus are

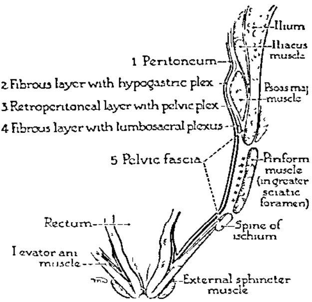


Fig. 145. Diagram of the relation of the main neural sheets to the pelvic fascial strata. (Ashley, F. L., and Anson, B. J., *Surg., Gynec. & Obst.*, May 1946.)

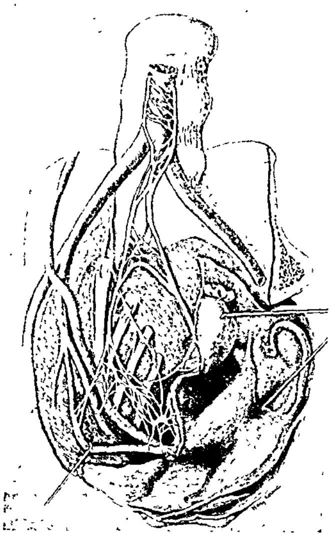


FIG. 144. The presacral nerve. Dissection shows the bifurcation of the superior hypogastric plexus into right and left inferior hypogastric nerves. In the pararectal space each inferior hypogastric nerve ends in the formation of the inferior hypogastric plexus. (Labate, J. S.: *Surg., Gynec. & Obst.*, 1938.)

fundamental relationship to the fascia, vascular supply and pelvic bony landmarks. These relations are of some surgical significance.

The superficial neural sheet is formed by sympathetic fibers from the superior hypogastric and inferior mesenteric plexuses which descend to the pelvis in the superficial subperitoneal tissue

2. Sympathetic fibers follow the branches of the middle hemorrhoidal vessels and innervate the lower rectal ampulla and the anorectal junction.

3. Sympathetic fibers are also carried by the inferior hemorrhoidal nerves. These are the parietal sympathetics, arising from the sacral and coccygeal ganglionated cord, which supply chiefly the glands and vessels of the skin surrounding the anal canal.

The terminal distribution of the autonomic nerves to the rectum consists of the two commonly described plexuses of Auerbach and Meissner (fig. 146).

The plexus of Auerbach—the intermuscular plexus—is of parasympathetic origin. It ramifies between the circular and longitudinal musculature of the rectum and continues in the conjoined longitudinal muscle to reach the perianal skin.

The plexus of Meissner (submucous plexus) is distributed mainly to the glandular apparatus of the mucosa. It ramifies in the submucous layer of the rectum and is disposed around and between the glands. Meissner's plexus probably continues below the epidermis of the anal canal (the anoderm) to reach the sweat, sebaceous and apocrine glands of the perianal skin This point is quite difficult to demonstrate, and the subject is further complicated by the extensions of the subepithelial plexus of the perianal skin which may be continuous with the plexus of Meissner or constitute a separate plexus According to Reuther, who has made a special study of this subject, the subepithelial plexus of the skin is continuous with that of the rectal mucosa (fig. 147).

The entire question of the terminal distribution of the nerves innervating the anal musculature and anorectal junction has been the subject of considerable speculation and investigation; it is of considerable neurophysiologic and clinical interest (for example, in pruritus ani). It has been described in great detail by Stöhr, who directs attention to the free anastomoses between the terminal arborizations, which he terms "intermuscular plexuses," containing sensory, motor and sympathetic end-plates.

It may be observed in this connection that the conjoined longi-

distributed with the branches of the superior hemorrhoidal arteries and their terminal branches to the internal hemorrhoidal annulus. These fibers continue below the anoderm to supply the anal canal and the perianal skin.

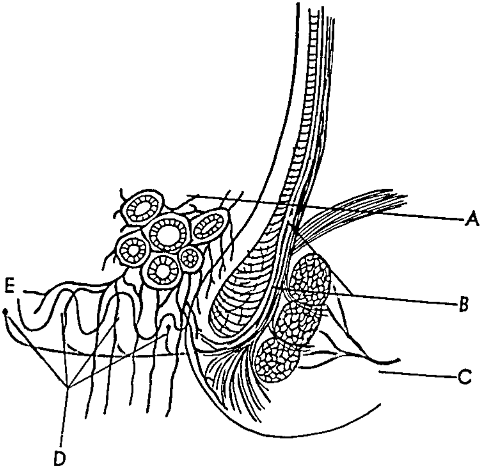


FIG. 146 The anorectal nerve supply. Note that in this schematic drawing the intermuscular plexus reaches the *perianal skin* in the fibro-elastic extensions of the conjoined longitudinal muscle. Note also that the glandular plexus of Auerbach is continued down to the perianal skin and becomes continuous with the subepithelial plexus which is not shown. A, Meissner's plexus to glands (sympathetic); B, Auerbach's plexus to muscles (parasympathetic); C, cerebrospinal to external sphincter and dentate line; D, corpuscles (Paccini, Krauss, Golgi, etc.); E, dentate line.

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It may be observed in this connection that the conjoined longi-

tudinal muscle, which includes fibro-elastic extensions from the striated levator ani muscle, as well as smooth muscle from the longitudinal coat of the rectum, presents an overlapping and interweaving of the nerve plexuses and end-organs which greatly complicates their exact anatomic terminations. Intermingled fibrils of both smooth and striated muscle are readily demonstrable in histologic sections of the anal canal (fig. 148). In con-

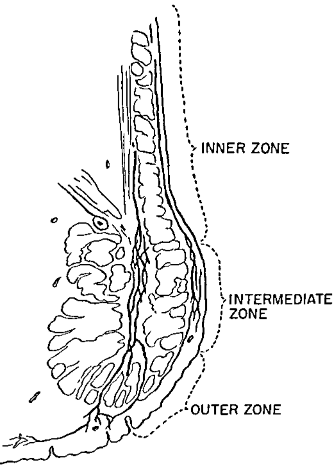


FIG. 147. Diagram showing the continuous subepithelial nerve network of the rectal submucosa and the anal skin, and the continuation of the intermuscular (Auerbach's) plexus supplying fibers to the external sphincter ani muscle. All medullated nerves have been omitted from the diagram. Redrawn from Reuther, T. F.: *Tr. Am. Proct. Soc.*, 204, 1940.

trast, a differentiation of the nerves and their distribution presents a complicated problem. In addition to the difficulties of differential staining, the precise effects resulting from separate nerve stimulation is further complicated by a direct mechanical

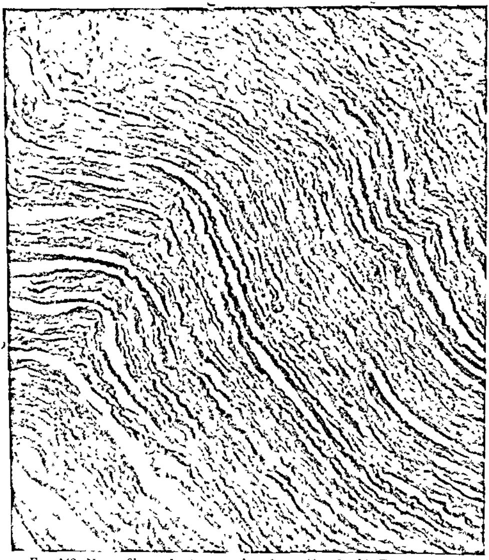


FIG. 148 Nerve fibers of intermuscular plexus (Auerbach). The fibers extend between the muscular fasiculi of the longitudinal muscle coat of the bowel wall. The section shown is just below the anorectal junction.

or contiguous stimulus invoked in the activities of these intimately integrated and co-ordinated muscles.

Innervation of the Anal Canal

The anal canal and its musculature receive cerebrospinal, sympathetic and parasympathetic innervation. The precise distribution of the terminal sympathetic plexuses, as previously noted, is not yet definitely settled.

The cerebrospinal *innervation, sensory and motor, is from the* third, fourth and fifth sacral nerves, supplemented by the smaller coccygeal spinal filaments. These are distributed by the peripheral nerves which reach the anal musculature, the squamous lining (anoderm) of the anal canal and the surrounding skin through the following branches (figs. 149–152).

1. Inferior hemorrhoidal nerve
2. Anterior sphincteral nerve
3. Perineal branch of the fourth sacral
4. Coccygeal spinal filaments

In general, the inferior hemorrhoidal nerves branching from the pudendal nerve follow the distribution of the arterial branches. After supplying the three divisions of the external anal sphincter, the terminal filaments end in the skin or the anal musculature or continue to the anorectal junction where they form a highly developed zone of end-organs or corpuscles (figs. 153–154).

The anterior sphincteral nerve, like the artery of the same name, arises independently from the pudendal nerve just before the latter divides into its terminal branches behind the triangular ligament. Directed transversely, the anterior sphincteral nerve supplies the anterolateral aspect of the anal musculature and adjacent skin. This nerve is commonly confused (as is the artery) with the superficial transverse perineal nerve which, however, lies in the superficial perineal compartment.

The perineal branch from the fourth sacral nerve pierces the

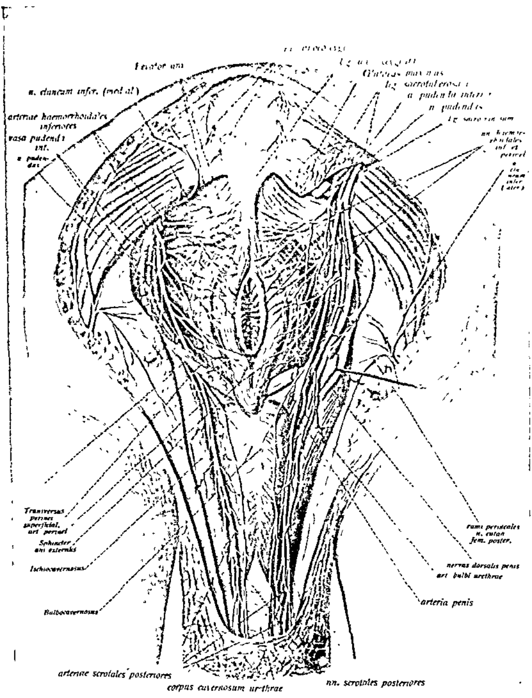


FIG 149 The nerve supply of the perineum (male). (Sobotta, J.: *Atlas der deskriptiven Anatomie des Menschen*, vol. 4. J. F. Lehmann, 1926.)

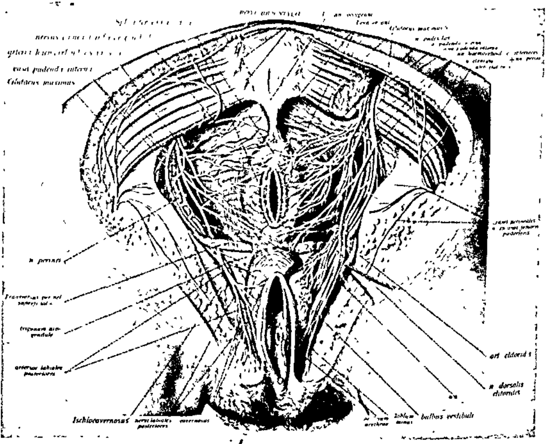


FIG. 150. The nerve supply of the perineum (female). (Sobotta, J.: *Atlas der deskriptiven Anatomie des Menschen*, vol. 4. J. F. Lehmann, 1926.)

coccygeus muscle and innervates the posterior aspect of the perianal skin. It sends but a few filaments to the musculature proper.

The coccygeal filaments are distributed anteriorly and posteriorly (fig. 155). The terminal posterior filaments ramify over the coccygeal skin and inosculate with the dermal branches of the fourth sacral. The anterior filaments ramify in the anococcygeal body and skin, and a small terminal filament from this plexus is sometimes referred to as the posterior sphincteral nerve of Moresten; *this, however, does not reach the sphincter musculature.*

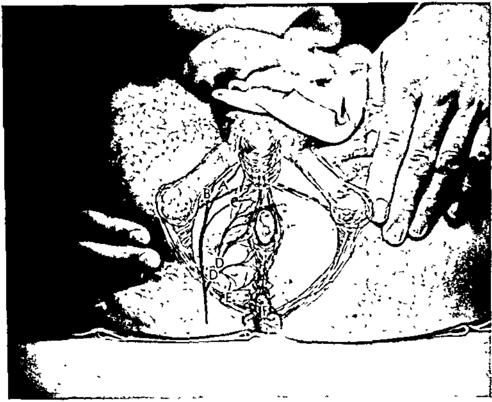


FIG 151 Perineal nerve supply (male) (Schematic projection to skin surface.) Local infiltration anesthesia particularly with the oil-soluble anesthetic, anucaine, should reach the main branches from the inferior hemorrhoidal and the anterior sphincterian nerve A, perineal nerve, B, pudendal nerve; C, anterior sphincterian nerve; D, inferior hemorrhoidals (there are sometimes three); E, fourth sacral nerve, F, anterior coccygeal branches

NEUROPHYSIOLOGY

Physiologically, defecation is not well understood but, like micturition (as described by Learmonth), it is perhaps best explained on the basis of a modified somatic autonomic reflex, normally under cortical control, in which the desire to defecate may be conveniently distinguished from the act of defecation. The so-called "trigger zones," or points at which the initial sensory stimuli arise and produce the desire to defecate, are probably in

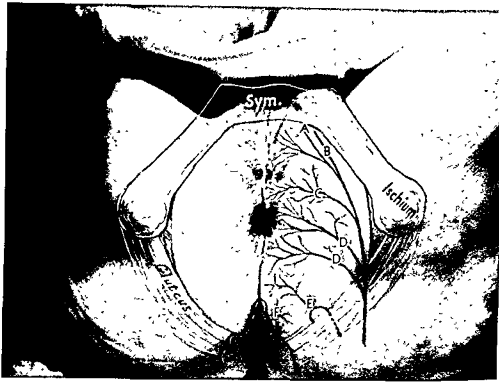


FIG. 152. Perineal nerve distribution (female). A, perineal nerve; B, pudendal nerve; C, anterior sphincterian nerve; D, inferior hemorrhoidal branch; E, fourth sacral nerve; F, coccygeal branches.

the rectal musculature as well as in the anorectal line which is the more important trigger zone. Threshold stimuli arise normally from the anorectal junctional area and, conveyed by the spinal sensory nerves, initiate the active phase of defecation. The distention of the rectal wall probably also gives rise to the desire to defecate through the sympathetic afferent nerves. This results reflexly in a relaxation of the anal sphincters, particularly the internal, and a contraction of the rectal musculature. The desire to defecate may be more or less continuous or intermittent and the act inhibited by the will.

On the other hand, voluntary relaxation of the anal sphincters with voluntary contraction of the colon and its complimentary muscles with expulsion of the rectal contents is the actual act of



FIG. 153. Terminals of nerve fibers in the region of the dentate line.

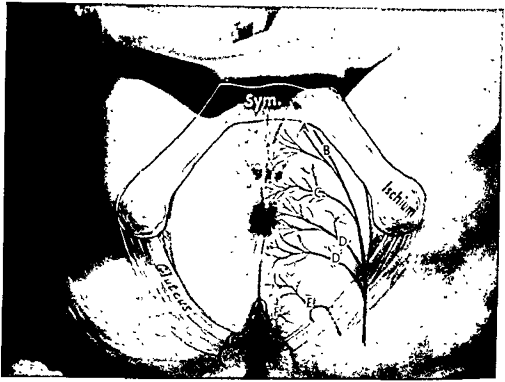


FIG. 152. Perineal nerve distribution (female). A, perineal nerve; B, pudendal nerve, C, anterior sphincterian nerve; D, inferior hemorrhoidal branch; E, fourth sacral nerve; F, coccygeal branches.

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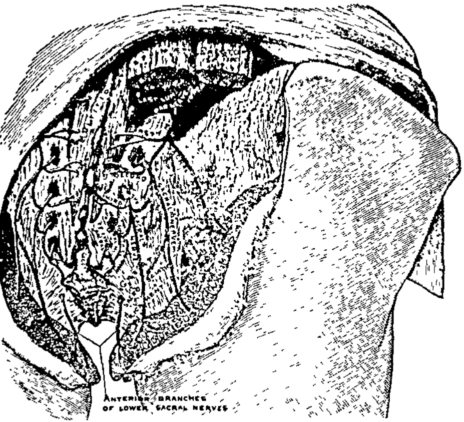


Fig. 155 The posterior sacral nerves. (Gray, H : *Anatomy of the Human Body*, Ed. 23 Lea and Febiger, 1936)

defecation. In this case, the reflex mechanism is subject to the control of the will. However, the reflex mechanism of the desire to defecate may be powerful enough to consummate the act, despite the voluntary control, as is well known.

In adult life defecation is no longer reflex but normally becomes a voluntary act, once the summation of sensory stimuli is effected. It becomes a purely reflex act, however (sympathetico-parasympathetic), in the "automatic" rectum following destruction of its cerebral connections.

The broad subject of constipation is directly related to the sensorimotor responses of the entire gastrointestinal tract as well as those of the rectum and anal canal.



FIG. 154 Nerve fibers shown in fig 153 (×400).

abnormal sensibilities, of which pain is the commonest, may be provocative of visceral dysfunction which, although usually of a functional nature, may be interpreted as organic, resulting in misdirected treatment. A laparotomy for fissure in ano is a possibility.

The relief sometimes afforded patients suffering from gastroduodenal spasticity, so-called spastic colitis, constipation etc., by a simple rectal operation probably has its basis in the abolition of pathologic reflexes.

The projection of referred symptomatology from the anorectal region to the genito-urinary apparatus, and vice-versa, need scarcely be mentioned. Prostatitis associated with a variety of psychoneurotic symptoms may also produce reflex pain, bearing-down sensations, burning, fullness, itching, etc., in the anorectal region. The sense of spurious and incomplete evacuation is common with hypertrophy of the prostate. The chronic anal spasm associated with chronic trigonitis, cystitis, eroticism, etc., is more common than recognized, and may be an etiologic factor in anal fissure.

Clinically those suffering from autonomic imbalance appear to have a disturbance in the regulatory influence of the central nervous system (cord, midbrain and brain) over the sympathetic visceral innervation, resulting in the syndromes called constipation, mucous colitis, spastic and atonic colons, etc., which are not well understood.

Whether definite histopathologic changes in the neuraxes and neurones underlie these conditions is a problem for the future.

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As noted by Alvarez, so-called *constipation may be a disorder of the nervous system in which the rectum cannot empty itself against the increased tonic contraction of the anal or levator sphincters.*

Spastic phenomena may additionally obtund the normal stimulus to defecation and or prevent distention of the rectum or the descent of the fecal mass, both of which normally initiate the stimulus for evacuation.

It may be noted that the act of defecation is not limited to the rectum alone. That the colon and sigmoid may also be prominently involved is clinically evident from the size and length of the fecal mass; the desire for a repetition of the act probably initiated by a mass wave of the colon.

"Trigger zones" may be entirely extrarectal and in pathologic conditions provoke a constant tenesmus leading to rectal prolapse. Further the sensory and motor dispersions before, after and during the act of defecation are complex and may be reflected *throughout the entire nervous system, e.g., fainting,* abdominal cramping, orgasms and neurocirculatory phenomena are common *clinical observations.*

Defecation may also be entirely a cortical response. Central stimulation of *the vagus produces the defecation reflex, a contraction* of the rectum and a relaxation of the anal sphincters.

In *this regard it may be observed that the segmental movements* of the intestines are considered myogenic in origin and that peristalsis is controlled by *the intrinsic plexuses of Meissner and* Auerbach. The autonomic system (sympathetic and parasympathetic) subserves a regulatory function. Diarrhea may *thus have* an entirely intrinsic myogenic basis.

Referred Symptomatology

Referred symptoms arising from pathologic conditions of the anorectal region, particularly to the abdominal viscera, are important from the differential diagnostic standpoint. Referred

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